DATA COLLECTION, ANALYSIS AND NUTRIENT CRITERIA DEVELOPMENT - PROGRESS REPORT

Lower Salinas River Watershed Nutrient TMDL
June 2010

Listed Water bodies: Alisal Creek, Alisal Slough, Blanco Drain, Chualar Creek, Esperanza Creek, Espinosa Slough, Gabilan Creek, Merrit Ditch, Moro Coho Slough, Natividad Creek, Old Salinas River, Quail Creek, Salinas Reclamation Canal, Salinas River (lower). Salinas River Lagoon (North), Santa Rita Creek, Tembladero Slough

Listed Conditions: Nitrate, Ammonia (unionized), Low Dissolved Oxygen, Chlorophyll-*a*, Unknown Toxicity, pH, Turbidity

Watershed Location: northern Monterey County.

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Salinas River @ Chualar (photo USGS)

DATA COLLECTION AND NUTRIENT CRITERIA DEVELOPMENT PROGRESS REPORT: LOWER SALINAS RIVER WATERSHED TMDL

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1 INTRODUCTION

This report compiles and documents relevant background information that pertains to, and may be utilized for, source analysis and nutrient criteria development for the Lower Salinas River Watershed nutrient TMDL.

The report also presents draft provisional draft nutrient targets for the Lower Salinas River watershed.

The report is divided into sections, and begins with general information on the project area and the currently identified impaired water bodies and designated beneficial uses. The report then documents and tabulates background and technical information that may be relevant to source analysis and the development of nutrient criteria.

The report concludes with a presentation of preliminary numeric endpoints for nutrients.

2 PROJECT AREA

The Project Area for this TMDL includes the watershed area contributing flow to the Salinas River Lagoon, the Old Salinas River, and Moss Landing Harbor upstream to the Salinas River crossing at Gonzales Road near the city of Gonzales. Therefore, the Project Area includes approximately 400 square miles of the lower Salinas River and Salinas Reclamation Canal watersheds. Figures 2-1 and 2-2 show the location of the Project Area.

Figure 2-1. Central Coast Region.

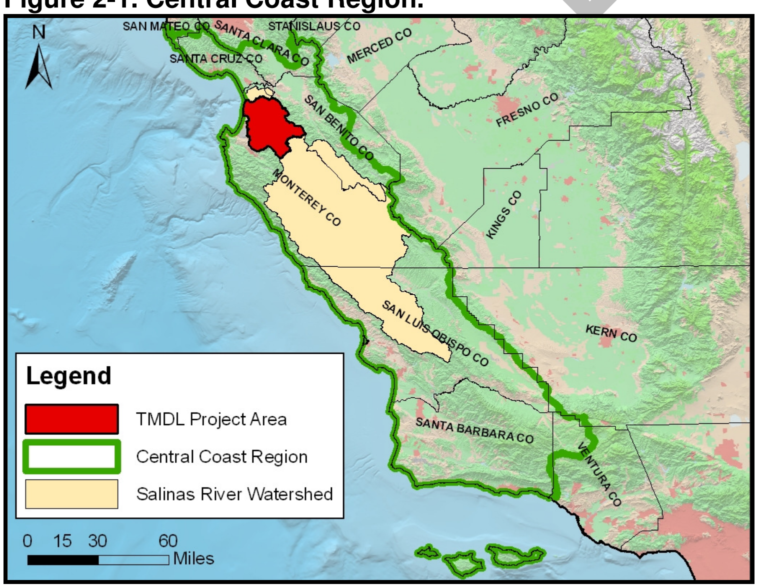
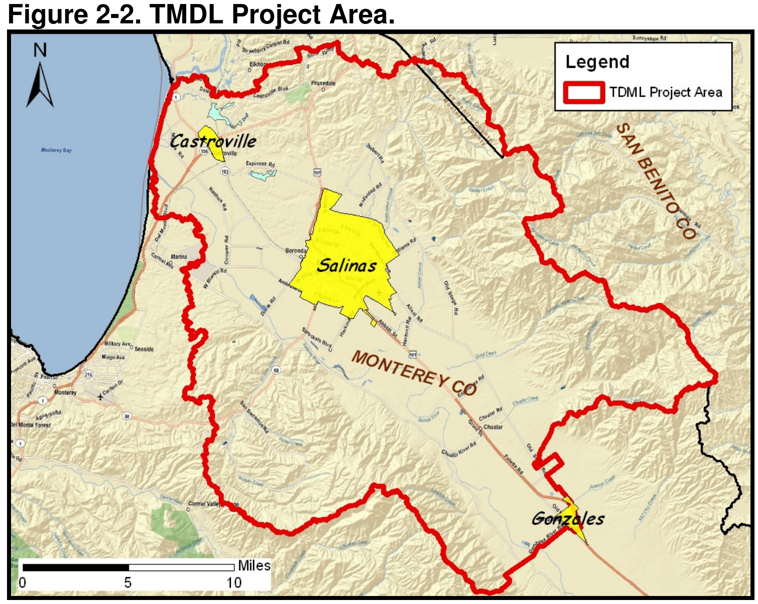


Figure 2-2. TMDL Project Area.



3 WATERSHED DESCRIPTION

3.1 Waterbodies

The project area is comprised of two major watersheds, identified here as the Reclamation Canal watershed[1], and the Lower Salinas River watershed. The Reclamation Canal watershed drains to the Old Salinas River and contains Tembladero Slough, and its tributaries: the Reclamation Canal, Espinosa Slough, Santa Rita Creek, Gabilan Creek, Natividad Creek, and Alisal Creek. The Lower Salinas River watershed drains to the Salinas River Lagoon[2], and contains the lower Salinas River and its tributaries: Blanco Drain, Toro Creek, Quail Creek, Esperanza Creek, and Chualar Creek. Waters from both the Reclamation Canal watershed and the Lower Salinas River watershed ultimately drain into Moss Landing Harbor, which is the receiving water located at the center of Monterey Bay. The Moro Cojo Slough subwatershed is also included in the project area. Moro Cojo slough is not directly hydrologically connected to the Lower Salinas River watershed or the Reclamation Canal watershed, but does ultimately drain to the same receiving water body – Moss Landing Harbor.

There is a limited hydrologic connection between the Reclamation Canal watershed and the Lower Salinas River watershed where the Salinas River Lagoon (North) periodically drains into the Old Salinas River through a slide gate at the northwest end of the Salinas River Lagoon (North). In the winter, the slide gate is often closed to prevent flooding in low-lying agricultural lands surrounding the Old Salinas River, and the inflows into the Salinas Lagoon are typically discharged directly into Monterey Bay through a breached sand bar at the mouth of the lagoon. Table 3-1 shows the two downgradient receiving water bodies and the tributaries to these receiving water bodies. Figure 3-1 shows the project area waterbodies and their connectivity.

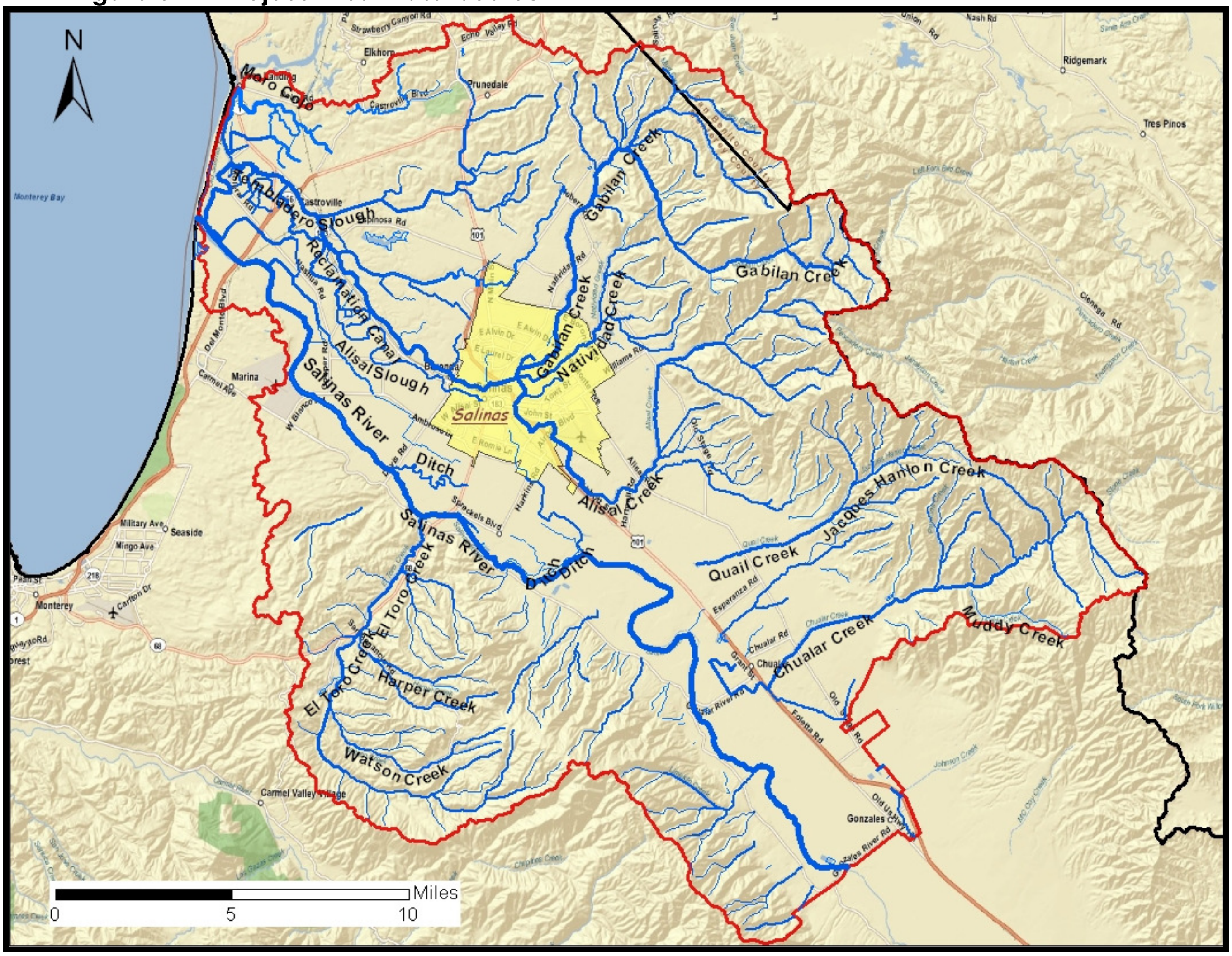
Table 3-1. Receiving water bodies and tributaries of the Project Area.

Coastal Confluence Receiving Water Bodies:		
Salinas River Lagoon	**Old Salinas River**	**Moss Landing Harbor**
Upstream Tributaries Discharging to the Above Receiving Water Bodies:		
Lower Salinas River	Tembladero Slough	Moro Cojo Slough
El Toro Creek	Salinas Reclamation Canal	
Blanco Drain	Santa Rita Creek	
Quail Creek	Gabilan Creek	

[1] The Salinas Reclamation Canal as listed in the Basin Plan, is the same waterbody that is sometimes identified locally as the Salinas Reclamation Ditch.
[2] Salinas River Lagoon is the same waterbody as Salinas River Lagoon (North), as listed in the Basin Plan. The two names are used interchangeably throughout this report.

Chualar Creek	Alisal Creek	
Esperanza Creek	Espinosa Slough	
	Natividad Creek	
	Alisal Slough	

Figure 3-1. Project Area Waterbodies.



3.2 Selection and Delineation of Subwatersheds

ESRI™ ArcMap® 9.2 was used to create watershed layers for the project area. Drainage boundaries within the Project Area were delineated on the basis of 1) the Watershed Boundary Dataset, which contain digital hydrologic unit boundary layers at the subwatershed scale (12-digit hydrologic unit code); and 2) elevation-derived catchments (drainage areas) available digitally from the National Hydrography Dataset Plus (NHDPlus).

Hydrologic Unit Codes (HUC) were developed by the United States Geological Survey (USGS) to identify all the drainage basins of the United States. NHD Plus catchments are drainage features, typically at a smaller scale than 12-digit hydrologic units, and are produced using a drainage enforcement techniques by the USGS, and the U.S. Environmental Protection Agency (USEPA).

The initial selection and delineation of the Project Area, and associated subwatersheds, was accomplished by digitally clipping the following 12-digit hydrologic units (HUC 12s) which are located within the Lower Salinas River valley (see Table 3-2):

Table 3-2. Project Area HUC 12 Subwatersheds.

HUC 12	HUC 12 NAME or NUMBER
180600051503	Limekiln Creek-Salinas River
180600051507	180600051507
180600051504	Chualar Creek
180600051506	Quail Creek
180600051509	Alisal Creek-Salinas River
180600110101	Mud Creek-Gabilan Creek
180600110102	Nativdad Creek-Gabilan Creek
180600110103	Alisal Slough-Tembladero Slough
180600110202	Bennet Slough-Frontal Monterey Bay (Moro Cojo Slough)

Within each HUC 12, higher resolution subwatershed delineation of project area stream reaches and associated drainage areas were accomplished by using NHD Plus catchment shapes as masks, and dissolving them together into larger polygons. Smoothed NHD Plus catchment shape files can be downloaded from the National Hydrography Dataset at:

http://www.horizon-systems.com/nhdplus/download.

Lastly, as a final quality control and refinement step, a 30-meter resolution digital elevation model (DEM) of the project area was created. Digital elevation data is available via the National Elevation Database (NED) developed by the USGS. DEM data is routinely used to drive slope and hydrologic attributes. Hydrologic attributes may be derived using the Hydrology Spatial Analyst tool extension available in ESRI™ ArcMap® 9.2. NED data is available from the U.S. Department of Agriculture Natural Resources Conservation Services, National Cartography & Geospatial Center at:

http://datagateway.nrcs.usda.gov/

In this project, the DEM was used primarily to refine subwatershed delineations located in very low-gradient valley floor areas, whose drainage catchments may not always adequately represented by the aforementioned HUC 12 and NHDplus catchment shape files. Figure 3-2 shows the 30-meter DEM model of the project area, and a DEM subwatershed delineation derived from a 10k flow accumulation grid.

Figure 3-2. DEM Model and DEM Subwatershed Delineations.

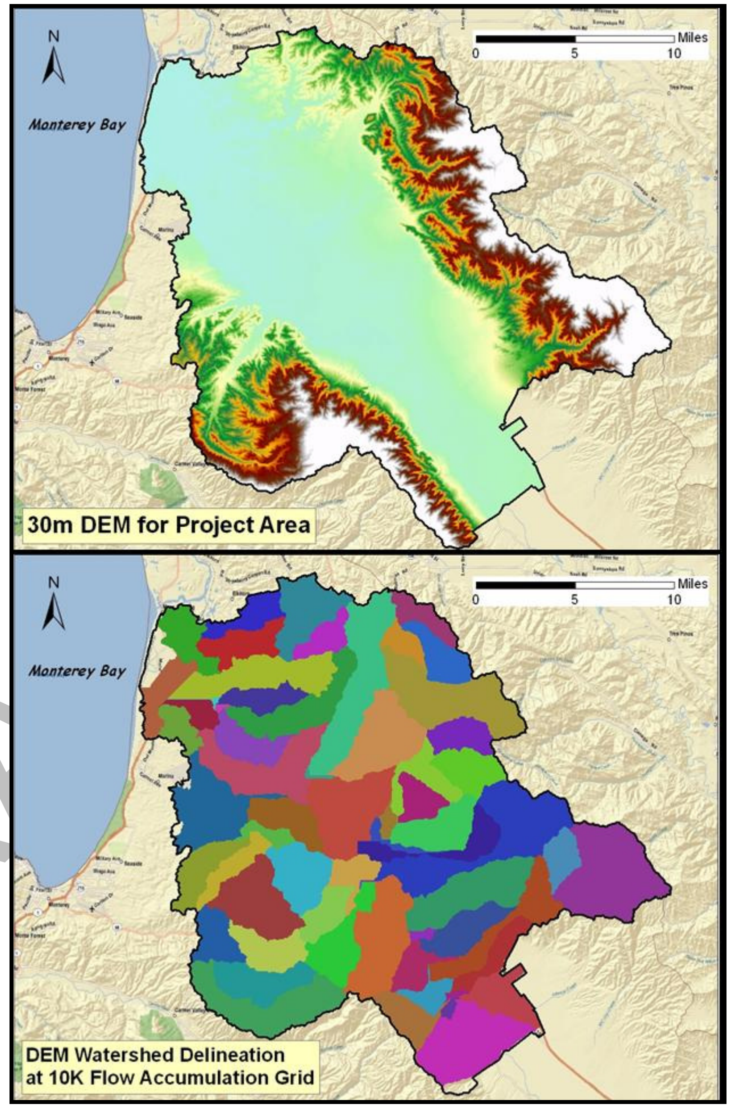


Figure 3-3 displays the individual subwatersheds developed for the Project Area. Table 3-3 identifies the names and the areal sizes of the subwatersheds.

Figure 3-3. Map of Subwatersheds in Project Area.

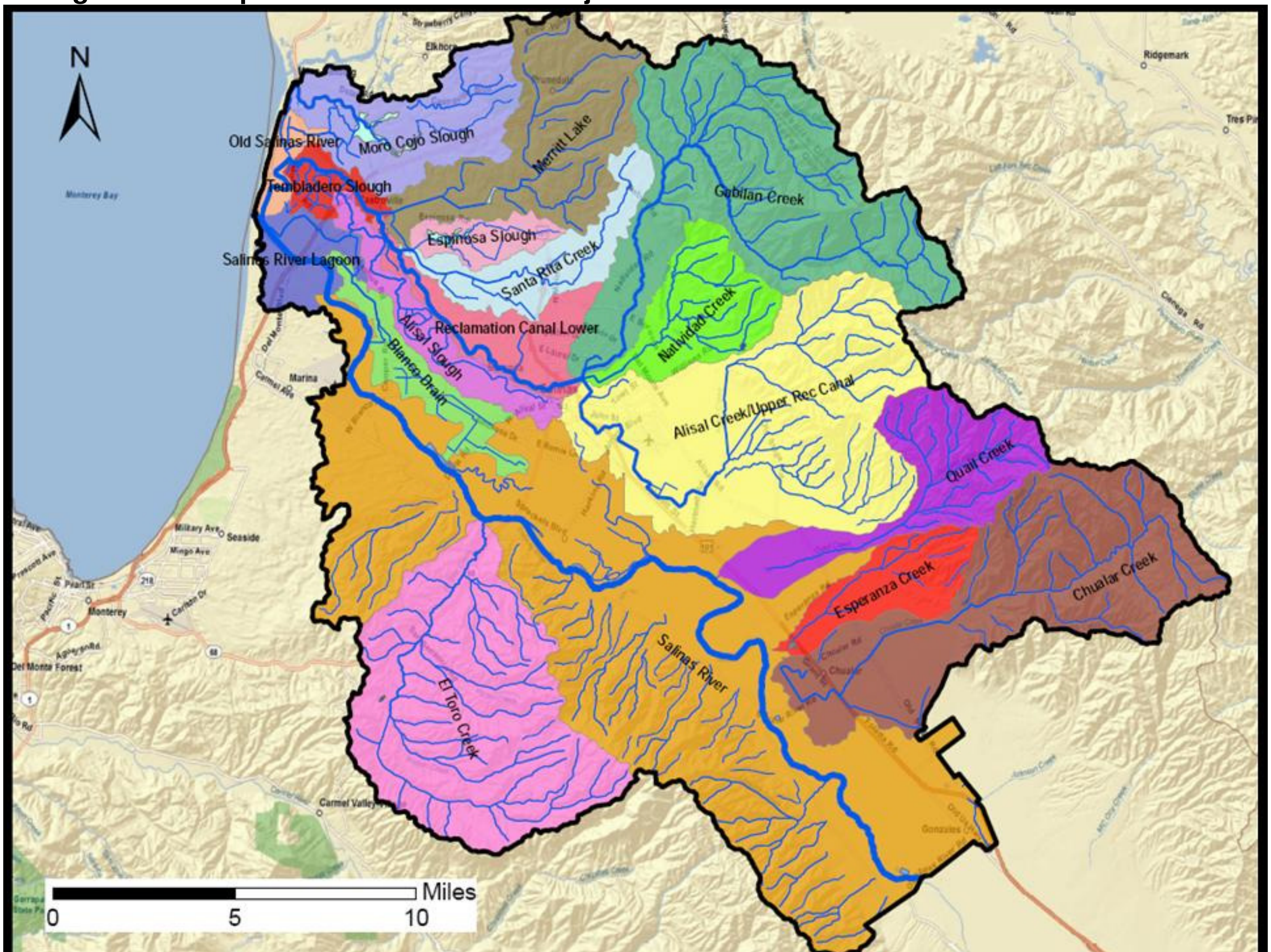


Table 3-3. List of Subwatersheds in Project Area.

Watershed	Area Acres	Area Sq. Miles
Old Salinas River	1492	2.3
Tembladero Slough	2154	3.4
Moro Cojo Slough	9836	15.4
Merritt Lake	14236	22.2
Salinas River Lagoon	3837	6.0
Lower Salinas River	69774	109.0
Blanco Drain	4442	6.9
Alisal Slough	4621	7.2
Reclamation Canal Lower	5729	9.0
Espinosa Slough	2655	4.1
Santa Rita Creek	6348	9.9
Gabilan Creek	27957	43.7
Natividad Creek	7337	11.5

Watershed	Area Acres	Area Sq. Miles
Alisal Creek/Upper Rec Canal	29656	46.3
Quail Creek	11097	17.3
Esperanza Creek	5687	8.9
Chualar Creek	25422	39.7
El Toro Creek	27062	42.3
TOTAL	**259342**	**405.1**

3.3 Hydrology

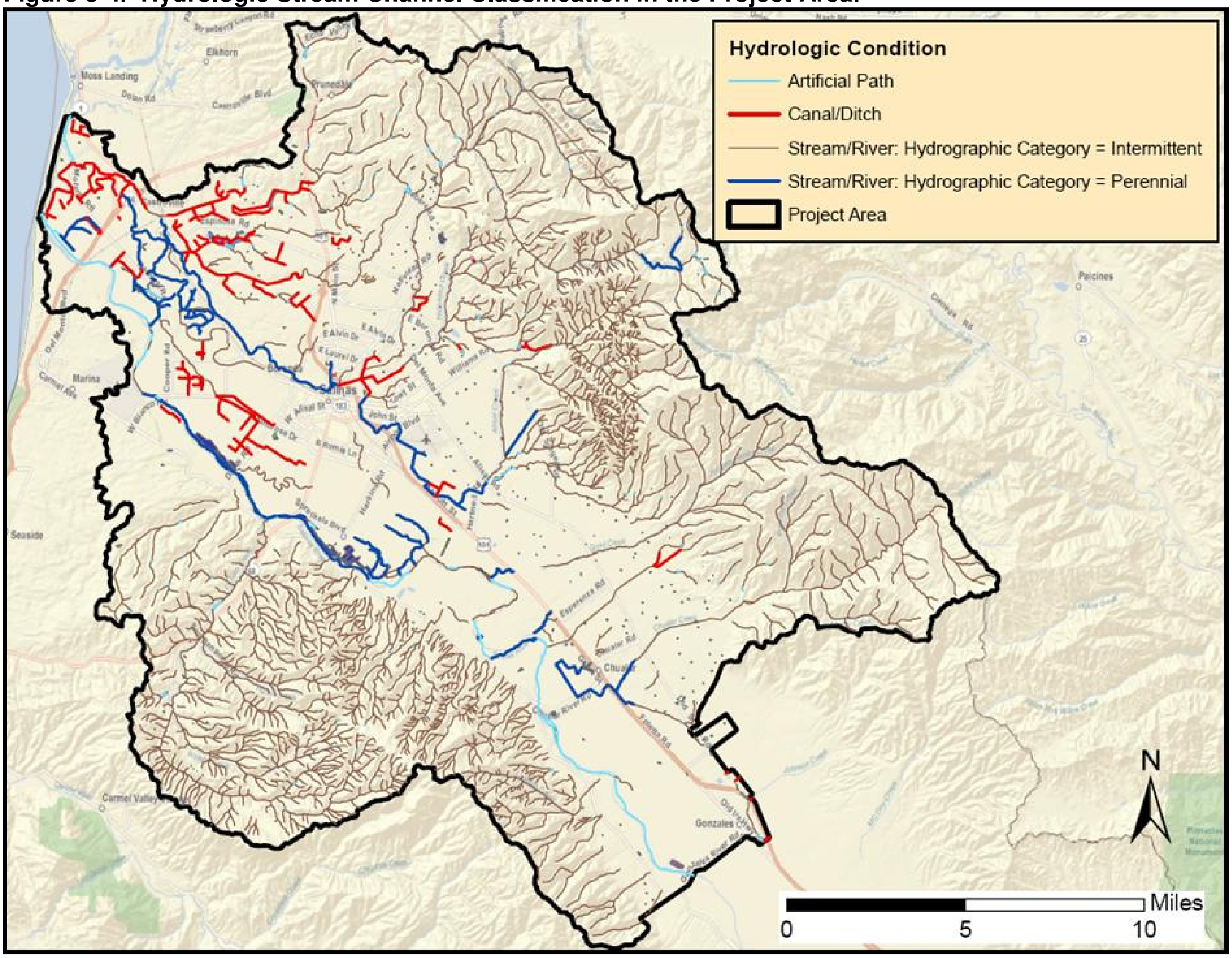
Assessing the hydrology of a watershed is an important step in evaluating the magnitude and nature of nutrient transport and loading in waterbodies. The entire drainage area contributing to flow in the Project Area (i.e., the Lower Salinas River watershed) encompasses over four thousand square miles (refer back to Figure 2-1). However, much of the runoff and precipitation generated throughout the entire Salinas River watershed is impounded in reservoirs, and periodically released for groundwater recharge, irrigation, or other purposes.

California Central Coast streams tend to have flashy hydrologic conditions with short durations of high flows following precipitation events, followed by long, extended periods of low or no flows. Low flow, baseflow conditions, or dry conditions (in ephemeral drainages) characterize stream reaches of the Project Area between rainy periods and throughout the dry season (May through October). Broadly speaking, many of the low-gradient, valley floor stream reaches and coastal confluence water bodies have perennial or near-perennial flows. This is attributable to the fact that these stream reaches receive base flow and/or discharges of urban and agricultural runoff during the dry season. The Salinas Reclamation Canal, Tembladero Slough, the Salinas River Lagoon, and the Old Salinas River are perennial; summer flows in these bodies of water are attributed to groundwater and irrigation sources. Because the Salinas River is a highly regulated water body, and flows are to a some extent, tied to dam releases, the Lower Salinas River was dry during the late summer months upstream of Davis Road (near the City of Salinas). Flow records from the USGS gage at Spreckles and the USGS gage at Chualar Bridge, indicate that the Salinas River in these reaches, have measurable flow approximately 60% of the year.

In contrast, many stream reaches located higher up (topographically upgradient) on the alluvial plain or in lower order headwater reaches (where there is less flow contribution from urban or agricultural runoff), flows tend to be intermittent or ephemeral (e.g., reaches of Gabilan Creek upstream of Hebert Rd). Also, these stream reaches may typically be underlain by deep alluvial deposits or fractured bedrock having high permeability; consequently surface flows tend to percolate into the subsurface. Note however, that in some cases lower order Project Area headwater reaches appear to have flow that are intermittent, or near-perennial (e.g., Towne Creek) based on the observation that water quality data has been collected throughout the year (including dry months) at monitoring sites associated with these reaches). These relatively more sustained headwater reach flows may potentially be due to baseflow, spring sources, and/or relatively impermeable bedrock (e.g., granitic bedrock in the Gabilan Range) which limit subsurface percolation of the surface flows.

Figure 3-4 illustrates the hydrologic stream channel classifications (perennial flow, intermittent flow, canal/ditch) in the project area. The source of these classification attributes is from the high resolution NHD dataset available at: http://nhd.usgs.gov/

Figure 3-4. Hydrologic Stream Channel Classification in the Project Area.



There are four active U.S. Geological Survey (USGS) flow gages in the Project Area (Figure 3-5). These active USGS flow gages include the Salinas River at Spreckles, the Salinas River at Chualar, Gabilan Creek, and the Reclamation Ditch. In addition, historic flow records (1961 through 2001) are available from discontinued USGS gage 11152540 at El Toro Creek. USGS flow data is available for download from the California Water Science Center at:

http://ca.water.usgs.gov/

Figure 3-5. Project Area USGS Flow Gage Stations.

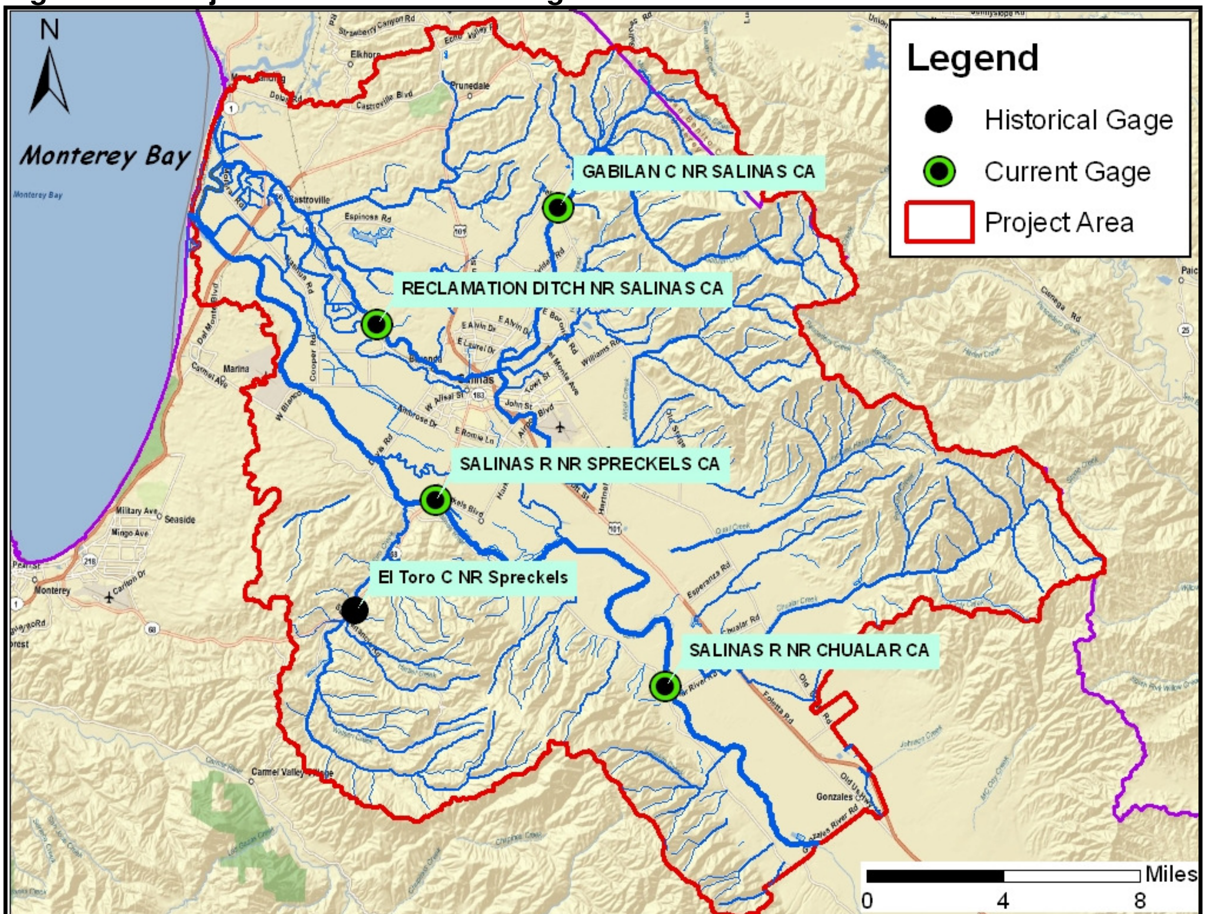
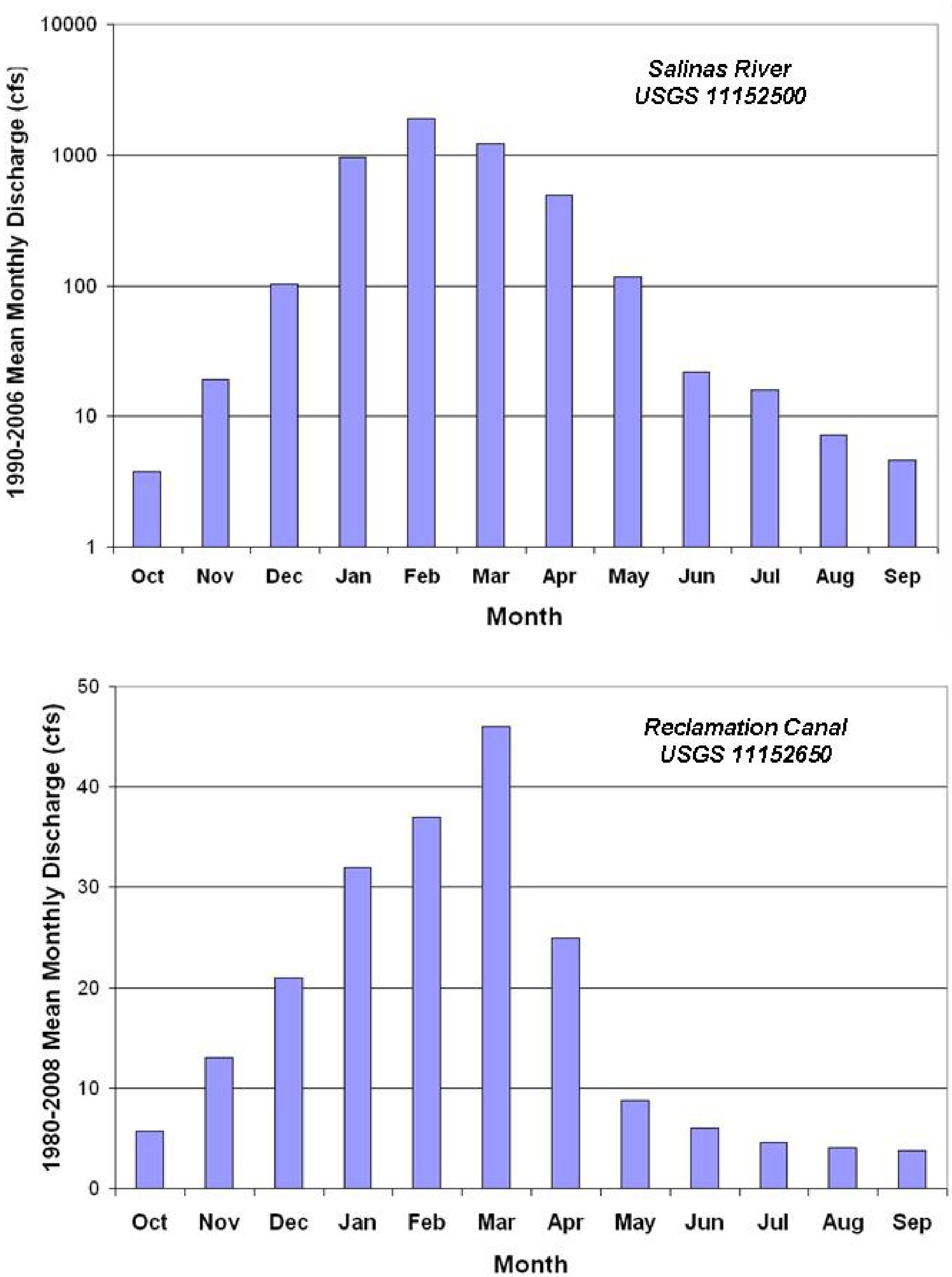


Figure 3-6 illustrates mean monthly flow in the Salinas River near Spreckles (1990 to 2006) measured at USGS gage 11152500 at Spreckles, California, and mean monthly flow (1980-2008) in the Reclamation Canal at USGS gage 11152650 (partial flow record). Note that the highest flows occurred from January to March, indicating the influence of precipitation on mean flow. Flows during the summer and early fall are attributed to inputs from irrigation and baseflow.

Mean annual discharge from the Salinas River watershed, as measured at USGS 11152500, is 268,699 acre-feet/year (flow record 1942-2008; drainage area 4,156 square miles). Mean annual discharge from the Reclamation Canal watershed, as measured at USGS 11152650, is 11,770 acre-feet/year (flow record 1971-2008; drainage area 53.2 square miles).

Figure 3-6. Flow Records for Lower Salinas River and Reclamation Canal.



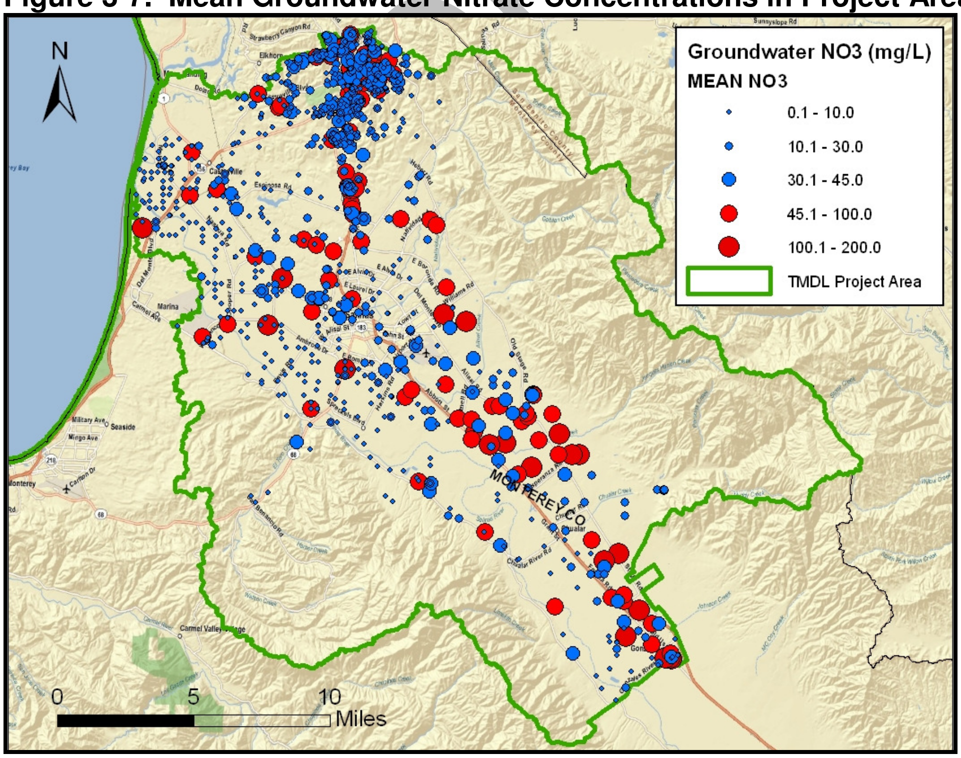
3.4 Groundwater

Groundwater (as baseflow) can be a source of nutrient loads to surface waters (USEPA, 1999). In addition, although TMDLs do not directly address groundwater quality problems, many surface waters are in fact designated for groundwater recharge beneficial use in the Basin Plan. Excessive nutrient concentrations in surface waters can potentially contribute to nitrate concentrations in groundwater. The Basin Plan describes nutrient-related water quality objectives that must be achieved for the protection of beneficial uses. With respect to groundwater, the nutrient-related Basin Plan water quality objective is shown below:

> Objectives for ground waters: "Ground waters shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Article 4, Section 64435, Tables 2 and 3."
>
> Title 22 states that nitrate (as NO_3) cannot exceed 45 mg/L (equivalent to nitrate-N of 10 mg/L-N). This objective applies to all ground waters.

Figure 3-7 is a bubble map illustrating mean NO3 concentrations in groundwater of the project area. The NO3 dataset shown in the figure was complied by Central Coast RWQCB staff from data obtained from USGS, Calif. Department of Public Health, Calif. Dept. of Water Resources, and other agency data. Note that red bubbles indicate where mean NO3 concentrations are in excess of the Basin Plan water quality objective) of 45 mg/L. Blue bubbles indicate ground water data where mean NO3 concentrations fall below 45 mg/L.

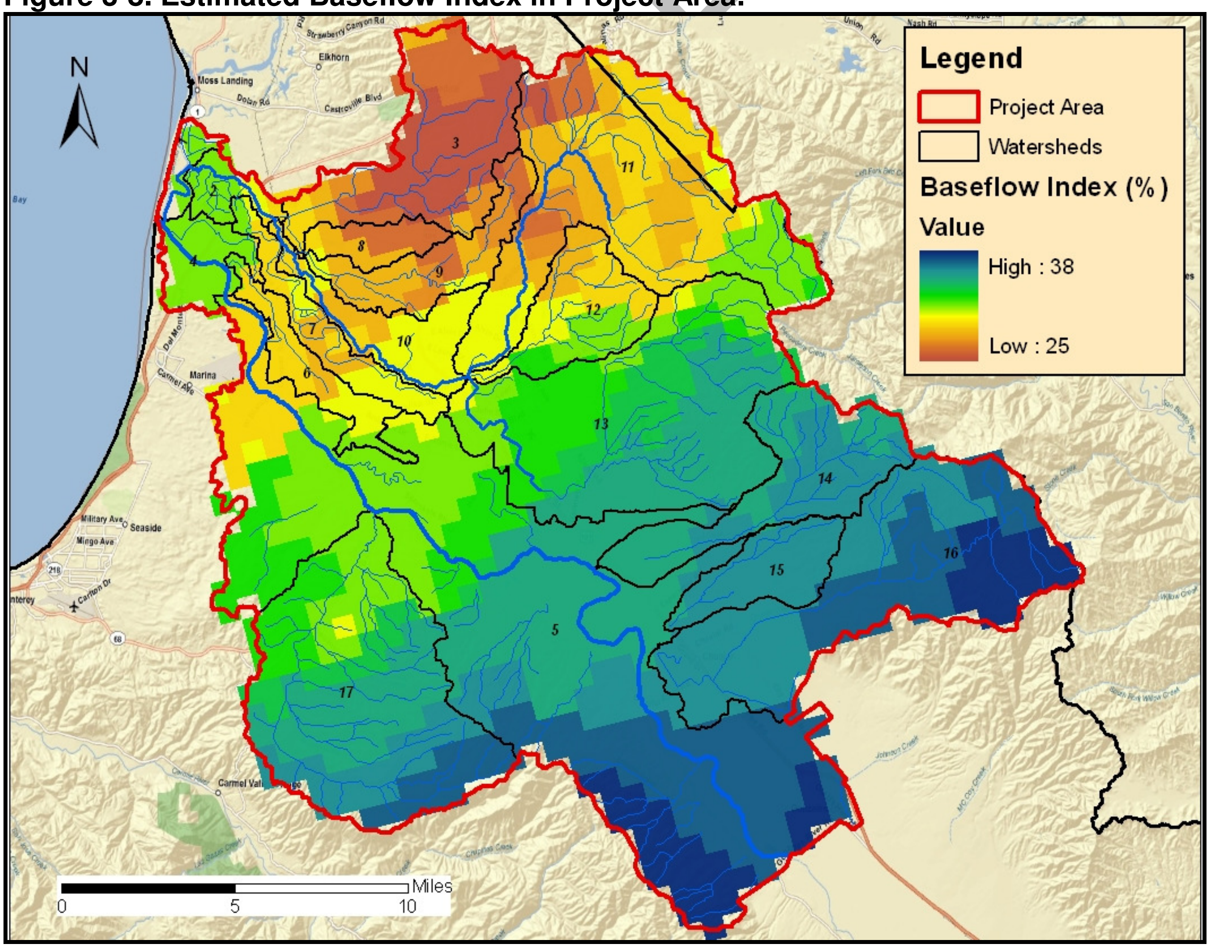
Figure 3-7. Mean Groundwater Nitrate Concentrations in Project Area.



Two impervious layers separate groundwater aquifers in the lower Salinas Valley (the low gradient floodplain from Gonzales downstream to the river mouth). The upper clay layer lies ten to twenty feet below the surface. The upper clay layer restricts percolating water from entering the deeper aquifer, thereby causing movement of water between the upper groundwater and area surface waters, e.g. the Salinas River and its tributaries. As such, ground water exfiltration to area water bodies is likely occurring. However, it is probable that much of the water percolating through the soil profile during summer months originates from agricultural irrigation.

Figure 3-8 broadly illustrates the nature of baseflow conditions throughout the project area, by depicting baseflow index. Baseflow Index (BFI) is the component of streamflow that can be attributed to groundwater discharges into streams. The BFI is the ratio of base flow to total flow. A higher BFI indicates a higher contribution of shallow, subsurface lateral flows into the stream reach, and consequently a higher likelihood of continuous or sustained flow through dry spells. The BFI grid shown on Figure 3-8 is a USGS raster dataset which is generated by interpolation from BFI point values estimated from USGS stream gages. The digital raster dataset is available from http://water.usgs.gov/GIS/metadata/usgswrd/XML/bfi48grd.xml#Identification_Information.

Figure 3-8. Estimated Baseflow Index in Project Area.



However, it should be noted that the USGS BFI raster is a broad approximation, interpolated from a few data points (i.e., stream gages), and the nature of perennial flows versus ephemeral flows throughout the Project Area will vary based on numerous factors. Also, BFI is really only a logical metric for perennial streams, and BFI ratios are not a quantitative metric to differentiate between ephemeral and intermittent streams. As such, Figure 3-8 represents a very generalized and qualitative illustration of the spatial potential for baseflow contributions.

3.5 Precipitation

The Lower Salinas Valley has a Mediterranean climate, with the vast majority of precipitation falling between November and April, as illustrated in Table 3-4 and Figure 3-9.

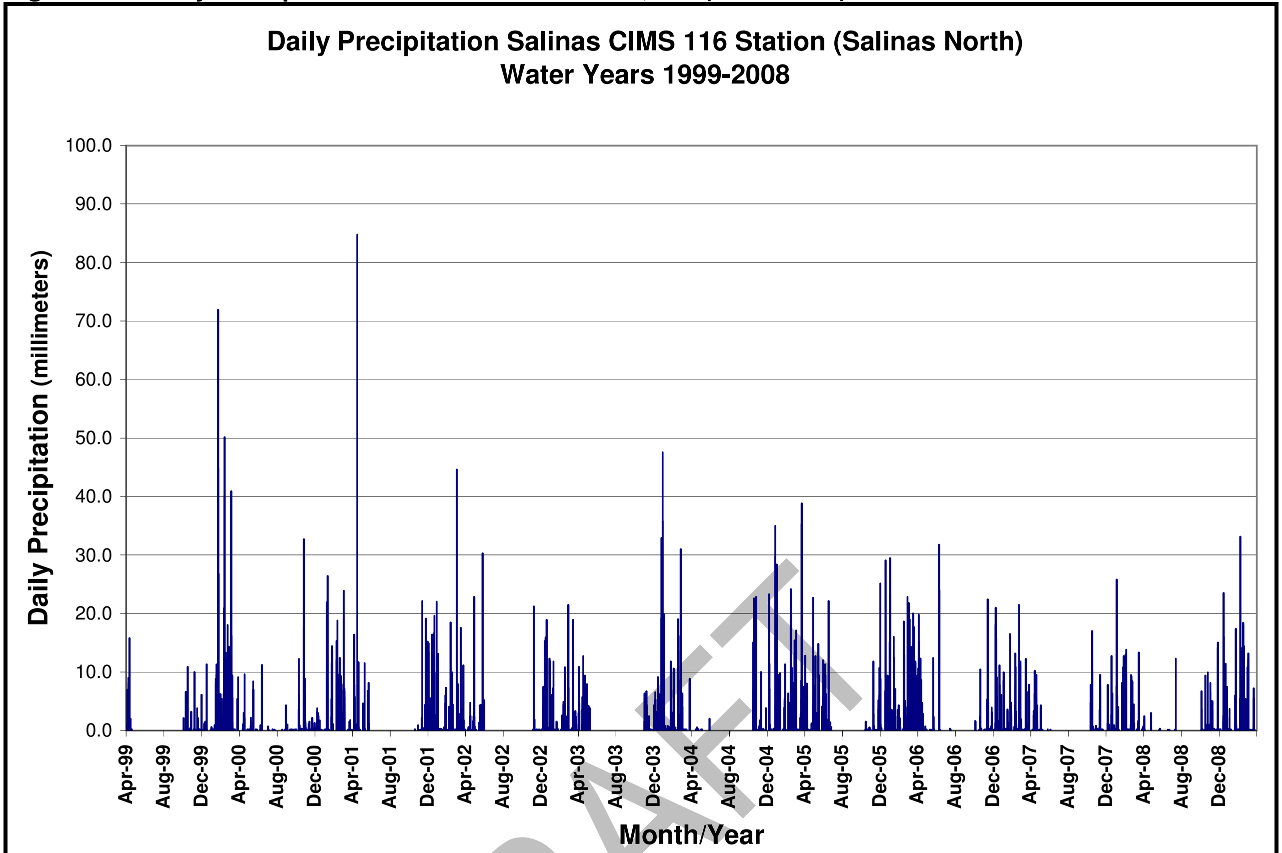
Precipitation data from weather gauging stations in the Project Area are available from the National Oceanographic and Atmospheric Administration - Western Regional Climate Center (http://www.wrcc.dri.edu), and from California Department of Water Resources - California Irrigation Management Information Systems website http://wwwcimis.water.ca.gov.

Table 3-4. Weather Station Precipitation Data.

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Salinas Airport[A] **(1930-2008)**	Average Total Precipitation (in.)	2.66	2.41	2.14	1.12	0.32	0.09	0.03	0.05	0.13	0.58	1.39	2.38	**13.29**
Salinas 2[A] **(1958-2008)**	Average Total Precipitation (in.)	2.89	2.68	2.33	1.13	0.3	0.1	0.03	0.06	0.24	0.62	1.76	2.46	**14.58**
Spreckels[A] **(1907-1988)**	Average Total Precipitation (in.)	2.83	2.27	2.17	1.14	0.35	0.11	0.03	0.04	0.22	0.55	1.44	2.29	**13.45**
Fort Ord[A] **(1968-1978)**	Average Total Precipitation (in.)	0.91	2.7	2.28	1.4	0.12	0.09	0.06	0.13	0.13	0.68	2.06	2.33	**14.89**
Castroville #19[B] **(1983-2007)**	Average Total Precipitation (in.)	2.94	3.33	2.13	0.98	0.67	0.35	0.31	0.21	0.37	0.68	1.76	2.70	**16.26**

A: Western U.S. COOP weather station (Source: NOAA Western Regional Climate Center)
B: California Dept. of Water Resources CIMIS station (Source: Calif. DWR-Irrigation Management Information System)

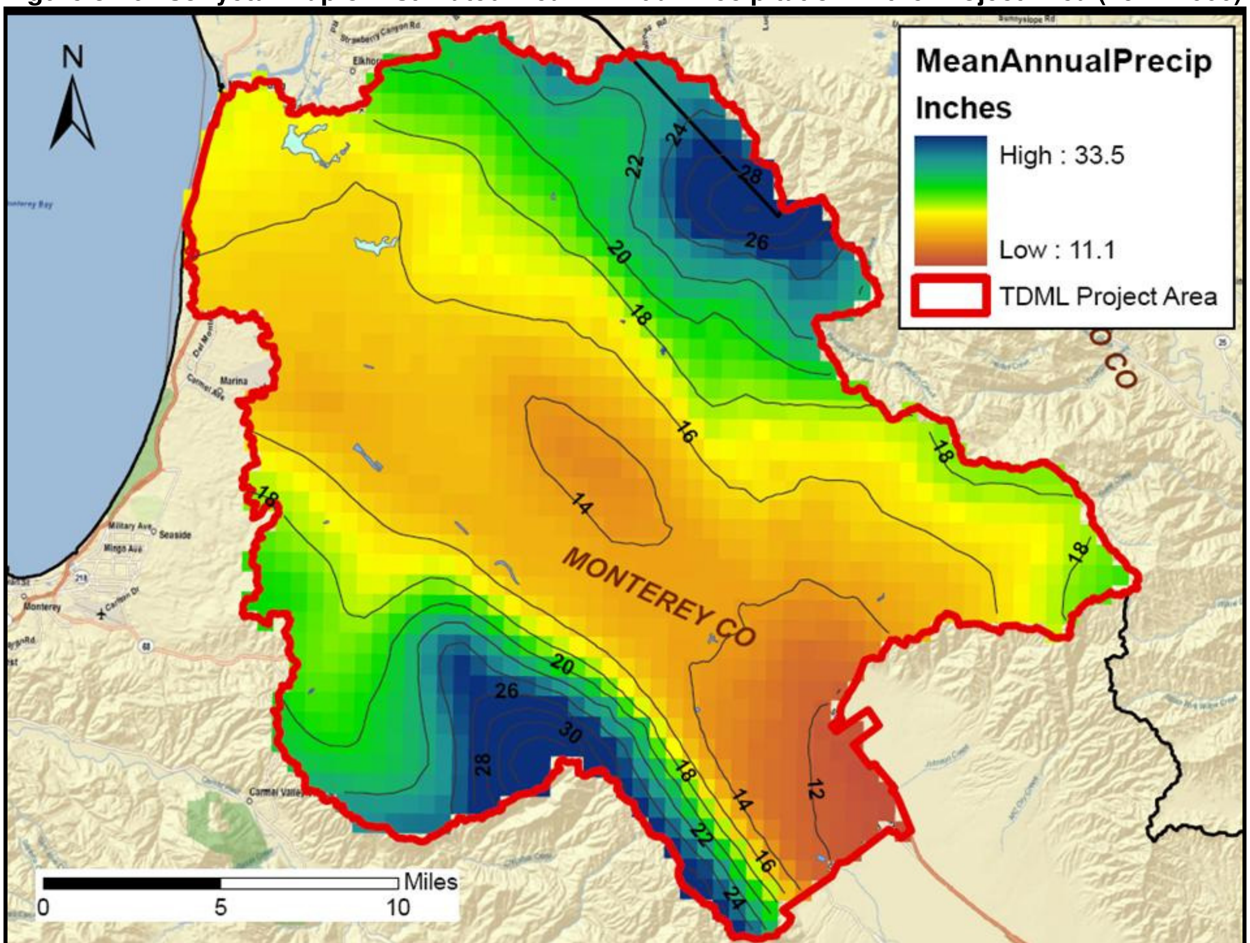
Figure 3-9. Daily Precipitation Record near Salinas, CA (1999-2008).



It is important to recognize the limited spatial distribution of rainfall gauging stations, and that gauging stations tend to be located in urban areas or valley floor areas. Consequently, these locations can bias estimates of regional rainfall towards climatic conditions at lower elevations. The topography of the California central coast region however, can result in significant orographic enhancement of rainfall (i.e., enhancement of rainfall due to topographic relief and mountainous terrain).

Therefore, mean annual precipitation estimates for the project area may be assessed using the *Parameter-elevation Regressions on Independent Slopes Model* (PRISM) (http://prism.oregonstate.edu/). PRISM is a climate mapping system developed by climate researchers at Oregon State University. The model accounts for orographic climatic effects and is widely used in watershed studies and TMDL projects to make projections of precipitation into rural or mountainous areas where rain gage data is often absent, or sparse. The PRISM data format is an interpolated grid which can be used in GIS, to make point measurements or digital grids of precipitation and other climatic factors to produce continuous, digital grid estimates of climatic parameters. Figure 3-10 shows an isohyetal map for mean annual precipitation in the Project Area based on PRISM data.

Figure 3-10. Isohyetal Map of Estimated Mean Annual Precipitation in the Project Area (1971-2000).



Accordingly, based on rain gage data and PRISM estimates, mean annual rainfall in the Project Area ranges from approximately 11 to 33 inches per year. Temporal/spatial variations result from seasonality (wet season versus dry season; Table 2-6), and local variation due to orographic effects (as illustrated in Figure 3-10).

Furthermore, an estimate of average annual rainfall in each individual Project Area subwatershed can be assessed with the PRISM data. The PRISM precipitation value associated with a pixel located at the mean center of each subwatershed can be assigned to represent average annual rainfall conditions within that subwatershed (for example, this was the methodology used in the Southern California Coastal Research Project, *"Estimates of Mass Emissions to the Southern California Bight Region*, Appendix A1 of Appendix A, page A1-3).

4 303(d) LISTINGS FOR NUTRIENT-RELATED IMPAIRMENTS

Final 2008 Update to the 303(d) List and 303(d)/305(b) Integrated Report for the Central Coast. Recommended Changes to the List of Impaired Waterbodies for waterbodies with nutrient or nutrient-related impairments in the lower Salinas River watershed are shown in Table 4-1.

Table 4-1. Listed Waterbodies

HU*	WATER BODY NAME	POLLUTANT NAME	LIST STATUS	TMDL DATE	2008 CHANGES
309	Alisal Creek (Monterey County)	Nitrate	TMDL Required	2013	Existing Listing
309	Alisal Slough (Monterey County)	Low Dissolved Oxygen	TMDL Required	2013	New - Add to List
309	Alisal Slough (Monterey County)	Nitrate	TMDL Required	2013	New - Add to List
309	Blanco Drain	Low Dissolved Oxygen	TMDL Required	2013	New - Add to List
309	Blanco Drain	Nitrate	TMDL Required	2013	New - Add to List
309	Chualar Creek	Ammonia (Unionized)	TMDL Required	2013	New - Add to List
309	Chualar Creek	Nitrate	TMDL Required	2013	New - Add to List
309	Chualar Creek	pH	TMDL Required	2013	New - Add to List
309	Chualar Creek	Temperature, water	TMDL Required	2013	New - Add to List
309	Chualar Creek	Turbidity	TMDL Required	2013	New - Add to List
309	Esperanza Creek	Nitrate	TMDL Required	2013	New - Add to List
309	Espinosa Slough	Ammonia (Unionized)	TMDL Required	2013	New - Add to List
309	Espinosa Slough	Nitrate	TMDL Required	2013	New - Add to List
309	Espinosa Slough	pH	TMDL Required	2013	New - Add to List
309	Gabilan Creek	Ammonia (Unionized)	TMDL Required	2013	New - Add to List
309	Gabilan Creek	Nitrate	TMDL Required	2013	Existing Listing
309	Gabilan Creek	pH	TMDL Required	2013	New - Add to List
306	Moro Cojo Slough	Low Dissolved Oxygen	TMDL Required	2021	Existing Listing

306	Moro Cojo Slough	pH	TMDL Required	2021	New - Add to List
306	Moro Cojo Slough	Ammonia (Unionized)	TMDL Required	2021	Existing Listing
309	Merrit Ditch	Ammonia (Unionized)	TMDL Required	2013	New - Add to List
309	Merrit Ditch	Low Dissolved Oxygen	TMDL Required	2013	New - Add to List
309	Merrit Ditch	Nitrate	TMDL Required	2013	New - Add to List
309	Natividad Creek	Ammonia (Unionized)	TMDL Required	2013	New - Add to List
309	Natividad Creek	Low Dissolved Oxygen	TMDL Required	2013	New - Add to List
309	Natividad Creek	Nitrate	TMDL Required	2013	Existing Listing
309	Natividad Creek	pH	TMDL Required	2013	New - Add to List
309	Old Salinas River	Chlorophyll-a	TMDL Required	2013	New - Add to List
309	Old Salinas River	Low Dissolved Oxygen	TMDL Required	2013	New - Add to List
309	Old Salinas River	pH	TMDL Required	2013	New - Add to List
309	Old Salinas River	Nitrate	TMDL Required	2013	New - Add to List
309	Quail Creek	Ammonia (Unionized)	TMDL Required	2013	New - Add to List
309	Quail Creek	Low Dissolved Oxygen	TMDL Required	2013	New - Add to List
309	Quail Creek	Nitrate	TMDL Required	2013	Existing Listing
309	Salinas Reclamation Canal	Ammonia (Unionized)	TMDL Required	2013	Existing Listing
309	Salinas Reclamation Canal	Low Dissolved Oxygen	TMDL Required	2013	Existing Listing
309	Salinas Reclamation Canal	Nitrate	TMDL Required	2013	New - Add to List
309	Salinas Reclamation Canal	pH	TMDL Required	2013	New - Add to List
309	Salinas River (lower, estuary to near Gonzales Rd	pH	TMDL Required	2013	New - Add to List

	crossing)				
309	Salinas River (lower, estuary to near Gonzales Rd crossing)	Nitrate	TMDL Required	2013	Existing Listing
309	Salinas River (lower, estuary to near Gonzales Rd crossing)	Nutrients	Remove from List		New - Remove from list
309	Salinas River (lower, estuary to near Gonzales Rd crossing)	Unknown Toxicity	TMDL Required	2013	New - Add to List
309	Salinas River Lagoon (North)	Nutrients	TMDL Required	2013	Existing Listing
309	Salinas River Refuge Lagoon (South)	pH	TMDL Required	2013	New - Add to List
309	Santa Rita Creek (Monterey County)	Ammonia (Unionized)	TMDL Required	2013	New - Add to List
309	Santa Rita Creek (Monterey County)	Low Dissolved Oxygen	TMDL Required	2013	New - Add to List
309	Santa Rita Creek (Monterey County)	Nitrate	TMDL Required	2013	Existing Listing
309	Tembladero Slough	Ammonia (Unionized)	Remove from List		New - Remove from list
309	Tembladero Slough	Chlorophyll-a	TMDL Required	2013	New - Add to List
309	Tembladero Slough	Nitrate	TMDL Required	2013	New - Add to List
309	Tembladero Slough	Nutrients	TMDL Required	2013	Existing Listing

5 BENEFICIAL USES

LOWER SALINAS RIVER WATERSHED: SUMMARY OF DESIGNATED BENEFICIAL USES FOR ASSOCIATED WATERBODIES

	SALINAS RIVER From Chualar to Spreckles	SALINAS RIVER Downstream of Spreckles	SALINAS RIVER LAGOON (NORTH)	OLD SALINAS RIVER ESTUARY	TEMBLADERO SLOUGH	SALINAS RECLAMATION CANAL	GABILAN CR.	ALISAL CR	QUAIL CREEK	BLANCO DRAIN
MUN	X	X					X	X	X	
AGR	X	X					X	X		

	SALINAS RIVER	SALINAS RIVER								
PRO	X									
IND	X									
GWR	X						X	X		
REC1	X		X	X	X	X	X	X	X	X
REC2	X	X	X	X	X	X	X	X	X	X
WILD	X	X	X	X	X	X	X	X		
COLD	X	X	X	X				X		
WARM	X	X	X	X	X	X	X	X	X	X
MIGR	X	X	X	X						
SPWN			X	X	X		X	X		
BIOL			X	X						
RARE			X	X	X					
EST			X	X	X					
FRESH		X								
COMM	X	X	X	X	X	X	X	X		
SHELL			X	X	X					

MUN: Municipal and domestic water supply.
AGR: Agricultural supply.
PRO: Industrial process supply.
IND: Industrial service supply
GWR: Ground water recharge.
REC1: Water contact recreation.
REC2: Non-Contact water recreation.
WILD: Wildlife habitat.
COLD: Cold fresh water habitat.
WARM: Warm fresh water habitat
MIGR: Migration of aquatic organisms.
SPWN: Spawning, reproduction, and/or early development.
BIOL: Preservation of biological habitats of special significance.
RARE: Rare, threatened, or endangered species
EST: Estuarine habitat
FRESH: Freshwater replenishment.
COMM: Commercial and sport fishing.
SHELL: Shellfish harvesting.

NOTE: Several project area waterbodies will are not identified in the beneficial uses table above, and will need to be included in the final beneficial uses table for pending project report.

6 DATA SOURCES AND DATA COMPILATION

Source analysis has not yet been conducted for this TMDL project. Generally speaking however, in any given watershed the following can potentially be significant sources of nutrient loads:

- Urban Runoff
- Wastewater Treatment Plants
- Fertilizer/Manure Applications
- Animal Feeding Operations (feedlots)

- Livestock
- Septic Systems
- Natural Background and Atmospheric Deposition
- Groundwater (baseflow into streams)

This section identifies and compiles water quality data and data pertaining to potential sources of nutrient loads. These data can potentially be utilized in evaluating sources of nutrient pollution in the project area.

To reiterate, **this compilation of data does not imply that these categories have been identified as probable sources of nutrient loads in the watershed. Source analysis for the TMDL project is pending. This report is only intended to compile sources of information that may pertain or be relevant to possible source categories.**

The basic mechanisms of nutrient transport to surface waters are relatively well established. Both nitrogen and phosphorus are transported to receiving waterbodies from rain, overland runoff, ground water (baseflow), and industrial and residential waste effluents. Phosphorus, because of its tendency to sorb to soil particles and organic matter, is primarily transported in surface runoff with eroded sediments. Inorganic nitrogen, on the other hand, does not sorb as strongly and can be transported in both particulate and dissolved phases in surface runoff. Dissolved inorganic nitrogen also can be transported through the unsaturated zone and ground water. Phosphorus associated with fine-grained particulate matter also exists in the atmosphere. This sorbed phosphorus can enter natural waters by both dry fall and rainfall. Finally, nutrients can be directly discharged to a waterbody by point and nonpoint discharges such as residential runoff, or untreated wastewater (USEPA 1999, 2000a; California Regional Water Quality Control Board, San Diego Region 2006).

6.1 Water Quality

Water quality data for nutrients, algae, dissolved oxygen, turbidity, pH, and other relevant parameters are available from:

- Central Coast Ambient Monitoring Program
- Central Coast Watershed Studies (CCoWS)
- Elkhorn Slough National Reserve Monitoring Program (ESNERR)
- Central Coast Water Quality Preservation, Inc.

The relevant data are embedded below:

S:\TMDLs & Watershed Assessme	S:\TMDLs & Watershed Assessme	S:\TMDLs & Watershed Assessme

Figure 6-1 and 6-2 show project area monitoring sites, and currently identified waterbodies that are impaired by nutrients or nutrient-related constituents.

Figure 6-1. Monitoring Sites.

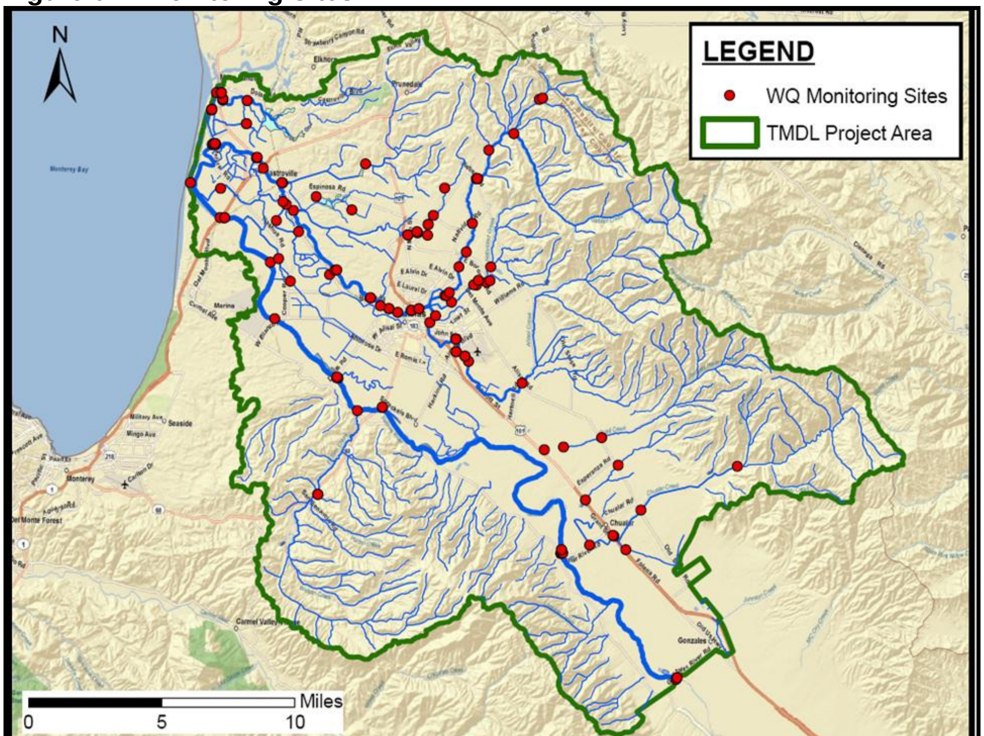
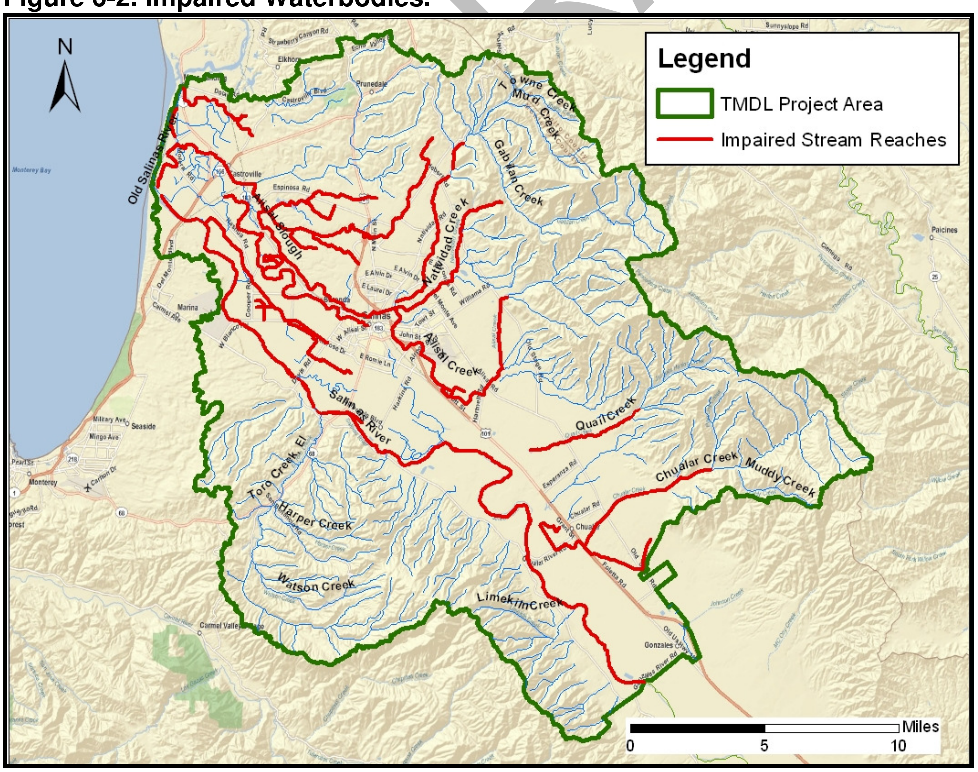


Figure 6-2. Impaired Waterbodies.



For illustrative purposes, Figures 6-3 and 6-4 show median total nitrogen and median total phosphorus throughout Monterey County. Note that median concentrations of these nutrients are elevated in the project area, relative to other areas of the county. Figure 6-5 through 6-7 illustrates the median and ranges of observed total nitrogen, total phosphorus, and chlorophyll a concentrations, respectively.

Figure 6-3. Median Total Nitrogen as N Concentrations.

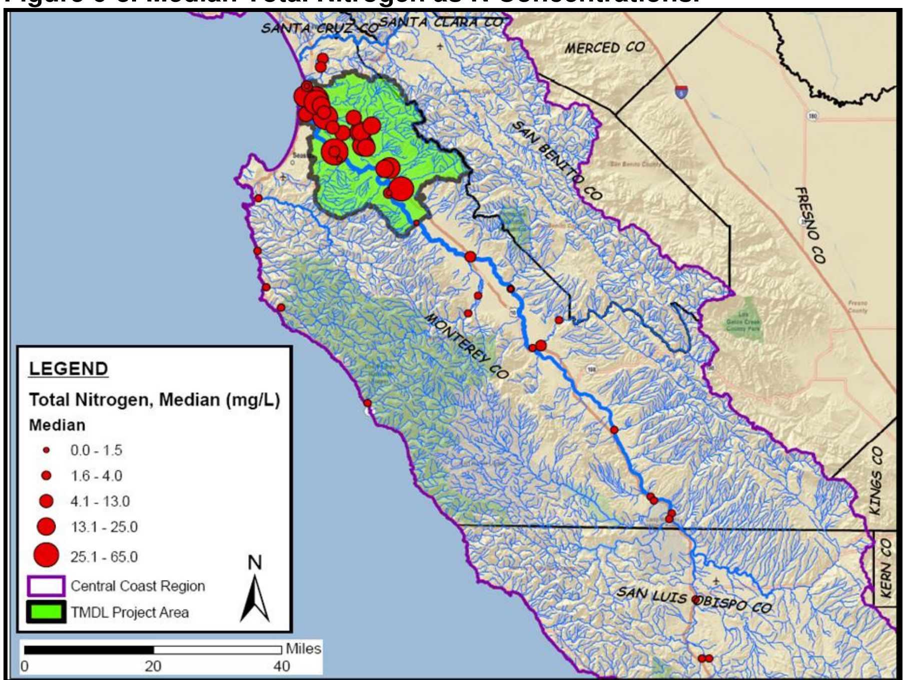


Figure 6-4. Median Total Phosphate as P Concentrations.

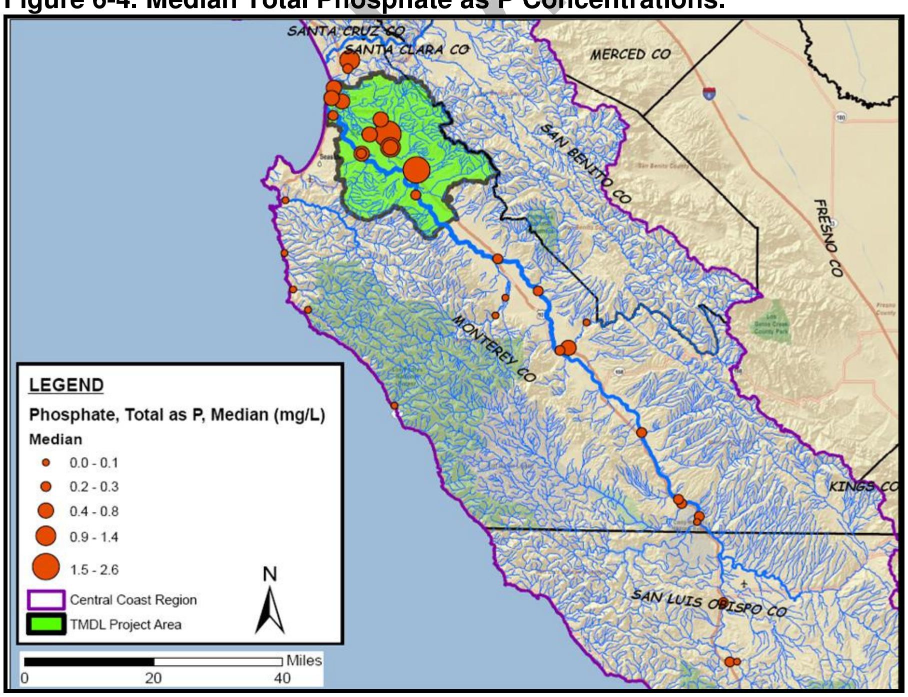


Figure 6-5. Total Nitrogen as N.

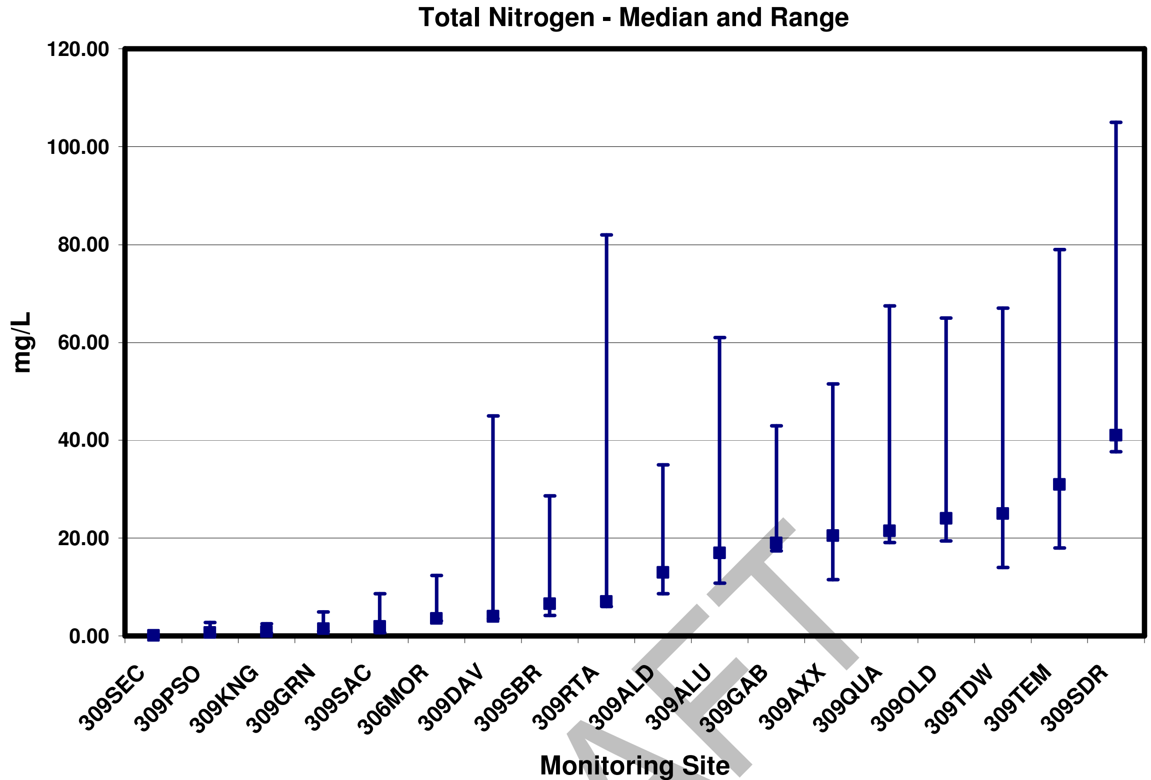


Figure 6-6. Total Phosphorus as PO4_P

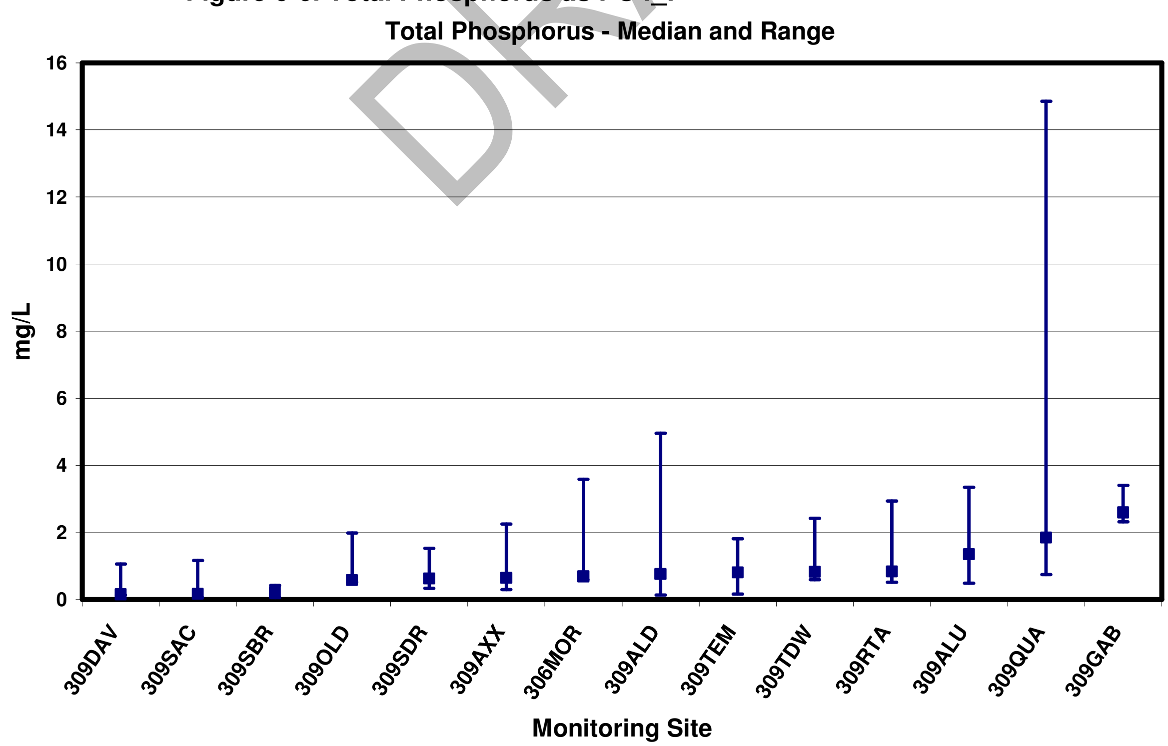
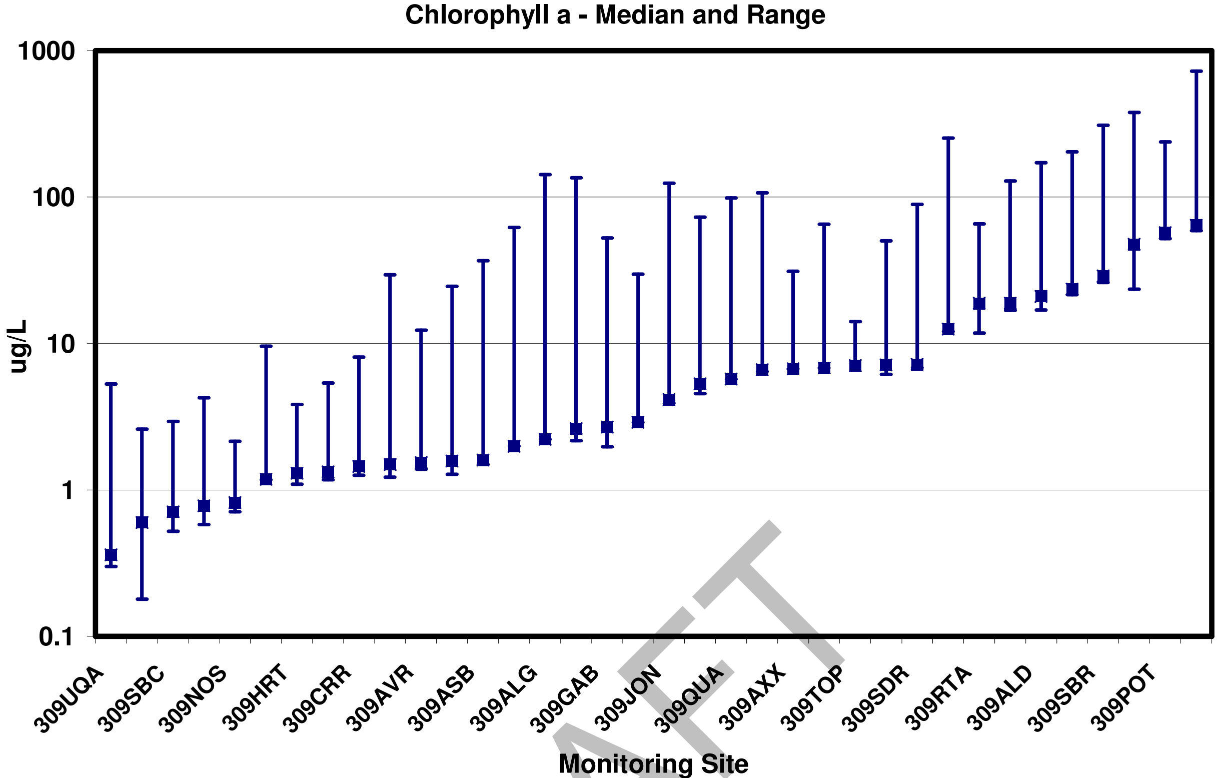


Figure 6-7.



6.2 Land Use and Land Cover

Land use and land cover in the project area can be evaluated from digital data provided by the California Department of Conservation Farmland Mapping and Monitoring Program (FMMP). The FMMP maps are updated every two years with the use of aerial photographs, a computer mapping system, public review, and field reconnaissance. For this data analysis report, the 2008 FMMP mapping data for Monterey County was used.

FMMP data is available for download from:
http://www.consrv.ca.gov/DLRP/fmmp/index.htm

Figure 6-8 illustrates land use and land cover in the project area. Table 6-1 tabulates the distribution of land use in the project area.

Figure 6-8. Land Use and Land Cover in Project Area.

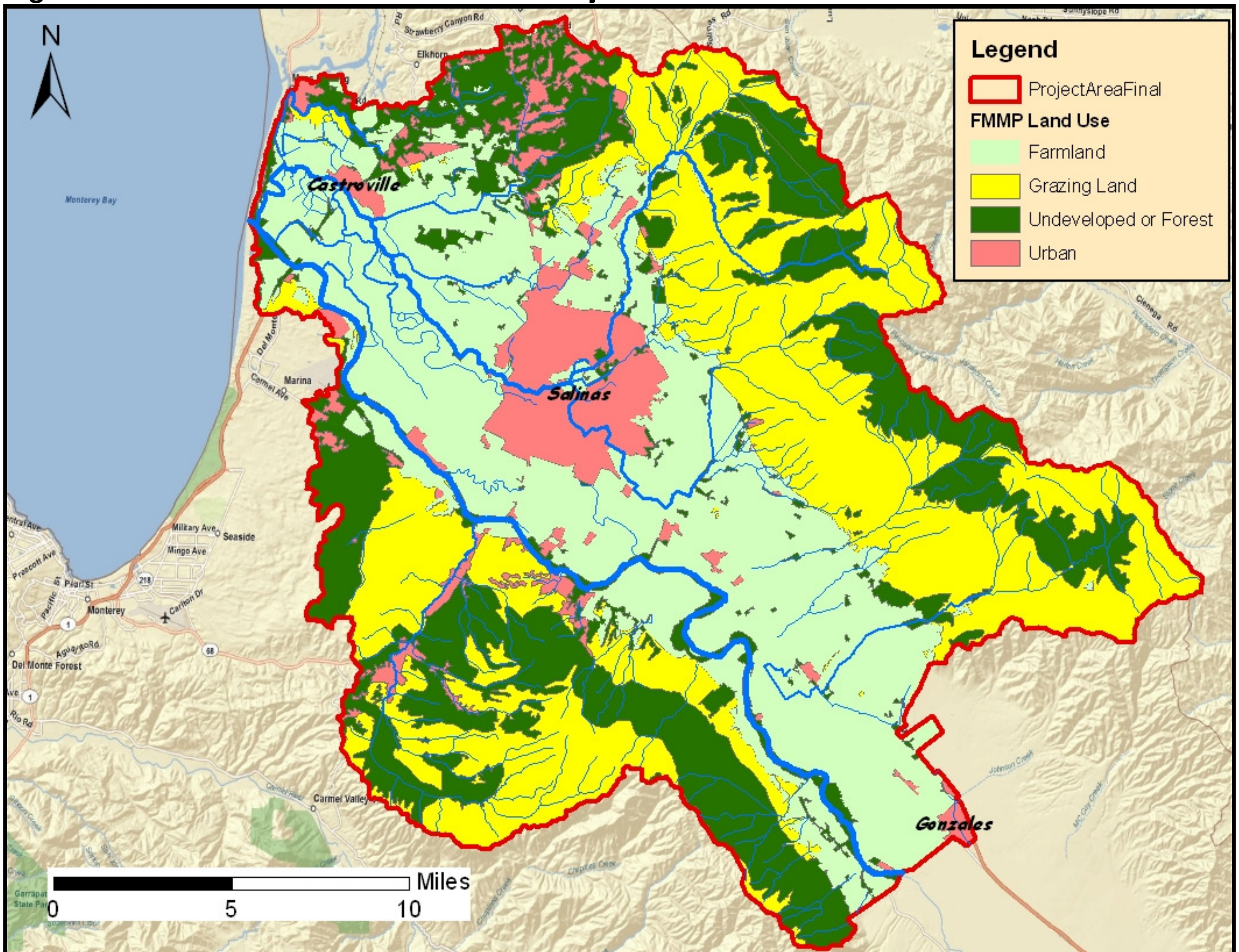


Table 6-1. Tabulation of Land Use and Land Cover in Project Area.

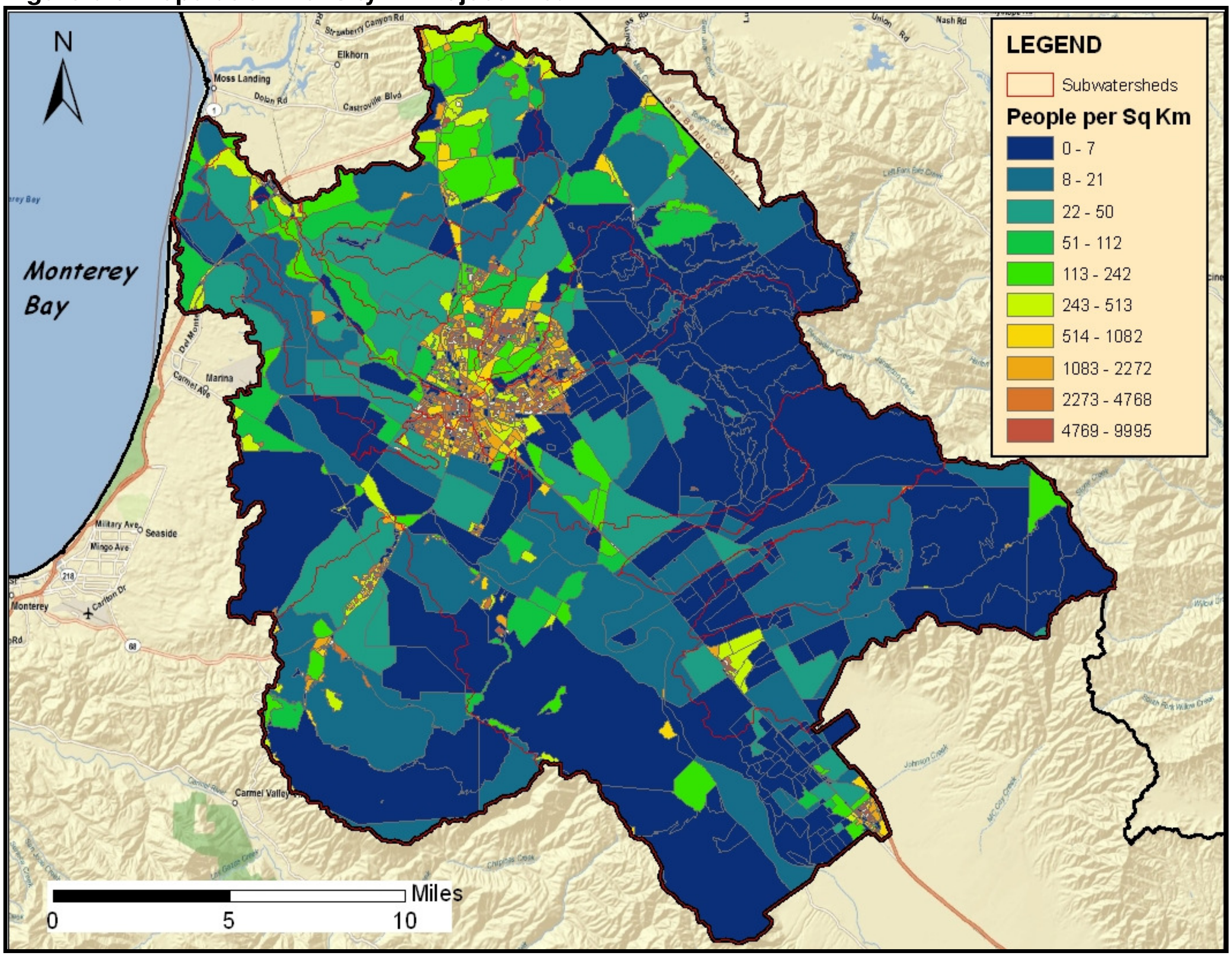
Land Cover	Acres
Urban	21463
Farmland	88240
Grazing Land	82307
Forest, Undeveloped, or Restricted	67330
Total	259341

6.3 Estimated Human Population and OSDS Census Data

Estimates of human populations, distributions, and associated sewage disposal practices (e.g., septic systems) are potentially important to ultimately consider in source analysis for nutrient TMDLs.

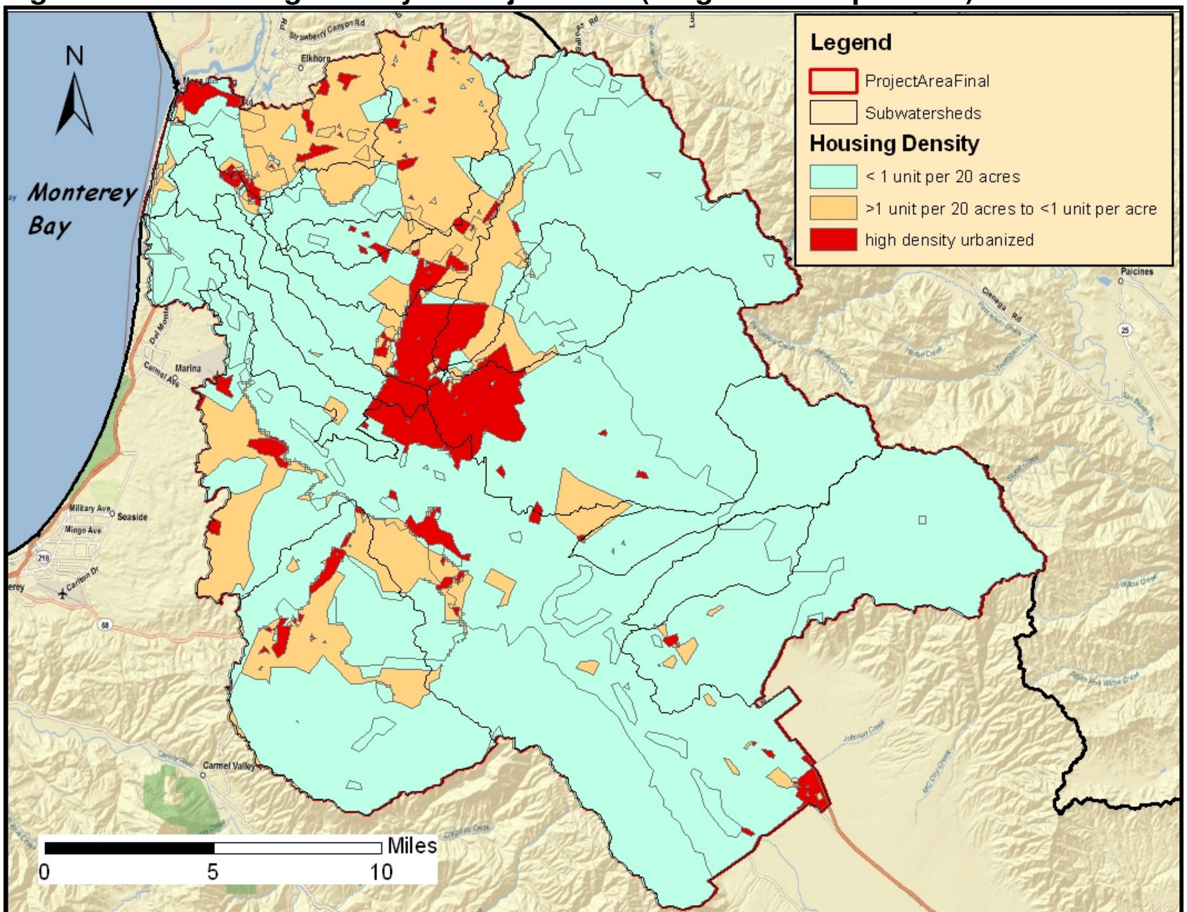
The population in the Project Area is 212,908 people according to Block data available from the U.S. Census Bureau 2000 Decennial Census. Figure 6-9 illustrates the range and distribution in population density (number of people per square kilometer) throughout the Project Area.

Figure 6-9. Population Density in Project Area.



Rural residential housing spatial density may be useful in assessing areas where septic contributions to surface water nutrient loads may be significant. Presumably, rural residential areas with relatively high housing density and that are located proximal to surface water bodies could be a risk for nutrient loads to surface waters from septic effluent. Housing density attributes may be extracted from the California Department of Forestry and Fire Protection (CDF) Management Landscape database available at: http://frap.cdf.ca.gov/data/frapgisdata/select.asp. Figure 6-10 illustrates housing density in the Project Area as extracted from the CDF Management Landscape database.

Figure 6-10. Housing Density in Project Area (range of units per acre).



The estimated number of housing units with Onsite Disposal Systems (OSDS, or septic tanks) may be obtained from the 1990 Decennial Census. The data is located at:

http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=datasets_1&_lang=en&_ts=

Unfortunately, household sewage disposal information was not included in the 2000 Census. Data from the 1990 can result in marginally underestimating the number of housing units using OSDS. If necessary and appropriate for future source analysis the 1990 OSDS census data can be made more current, by applying an upward adjustment to the 1990 Census numbers, assuming a 1% growth rate/year in the number of housing units in Monterey County with OSDS. The 1% growth rate/year comes from a Statewide OSDS survey conducted by Chico State University (2003).

Figures 6-11 and 6-12 shows the estimated OSDS spatial distribution, in census block groups in the project area. Figure 6-12 indicates that the areas with the highest density of OSDS and that are associated with an identified FIB-impaired waterbody are in the Santa Rita Creek watershed, Merrit Lake watershed, and the Tembladero Slough Watershed. High OSDS density is also observed in the lower El Toro Creek area; however there is currently insufficient data to determine if El Toro Creek is impaired by nutrients.

Figure 6-11. Percent of Houses with OSDS.

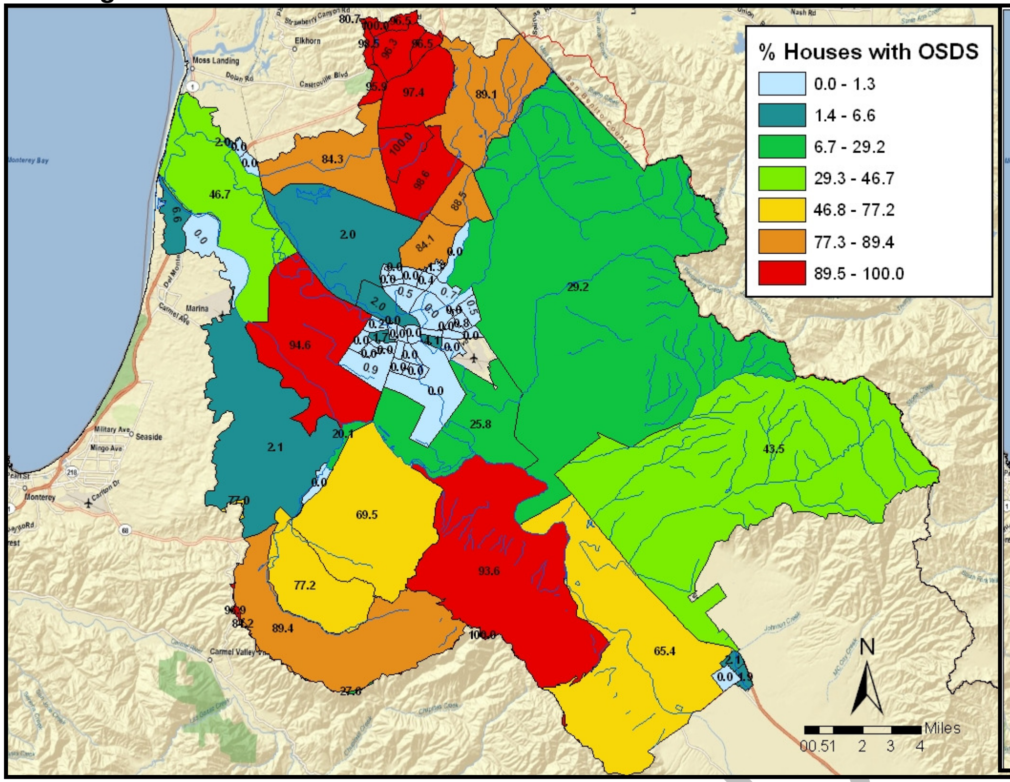
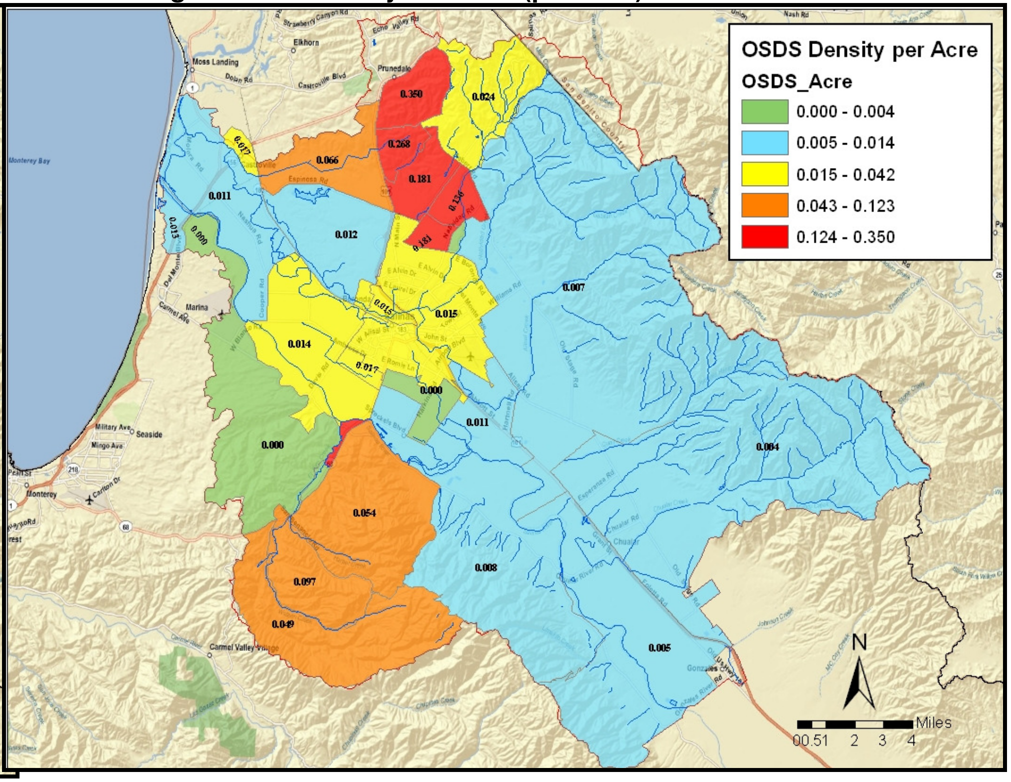


Figure 6-12. Density of OSDS (per acre).



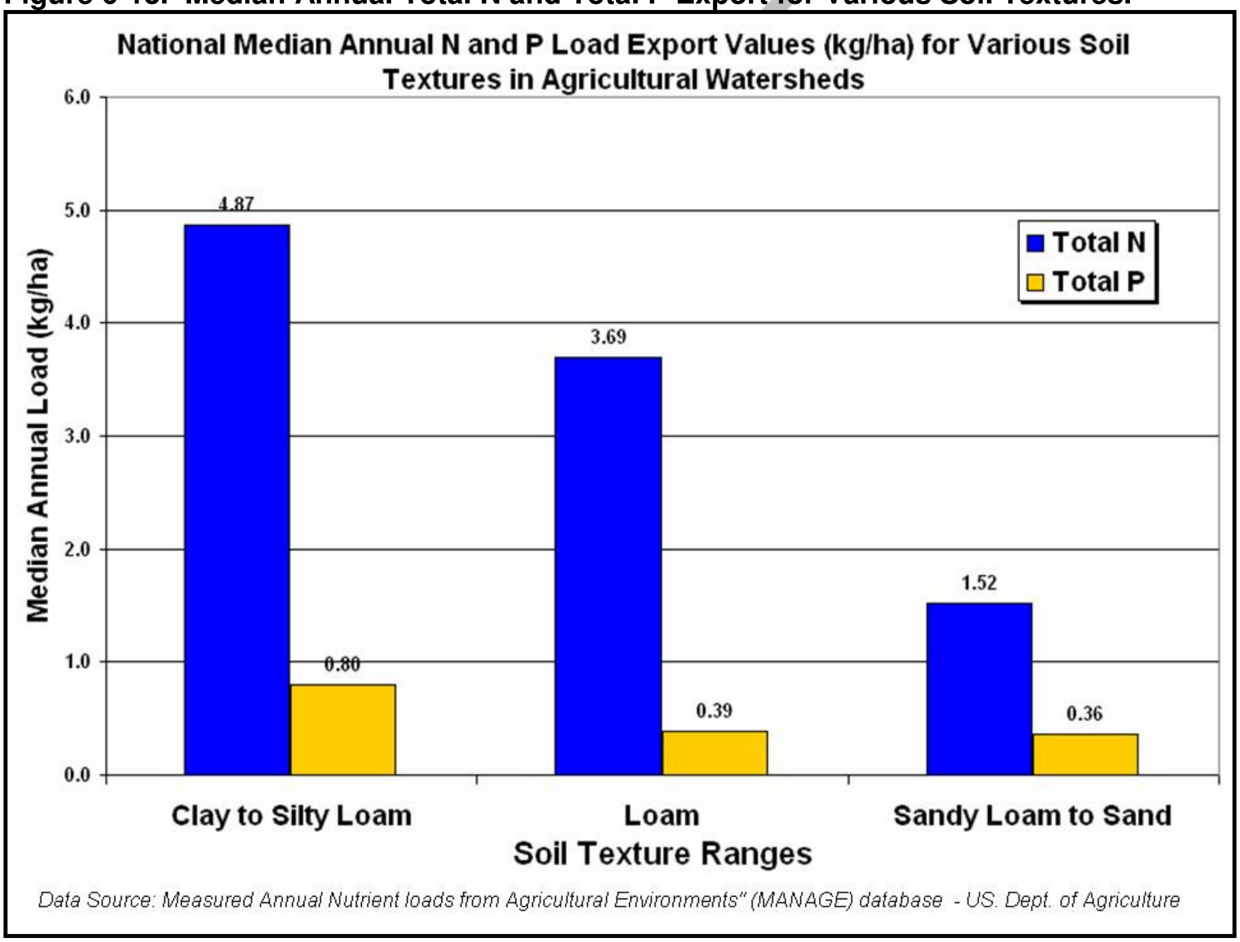
It is worth noting that septic tank disposal systems are not considered to be significant total phosphorus sources in ground water (Rainbow Creek Nutrient TMDL, San Diego Regional Water Quality Control Board, 2006) Phosphates readily adsorb to soil particles; consequently, phosphates do not travel far with ground water.

6.4 Soils

Soils have physical and hydrologic characteristics which may have a significant influence on the transport and fate of nutrients. Watershed researchers and TMDL projects often assess soil characteristics in conjunction with other physical watershed parameters to estimate the risk and magnitude of nutrient loading to waterbodies (Mitsova-Boneva and Wang, 2008; McMahon and Roessler, 2002; Kellog et al., 2006).

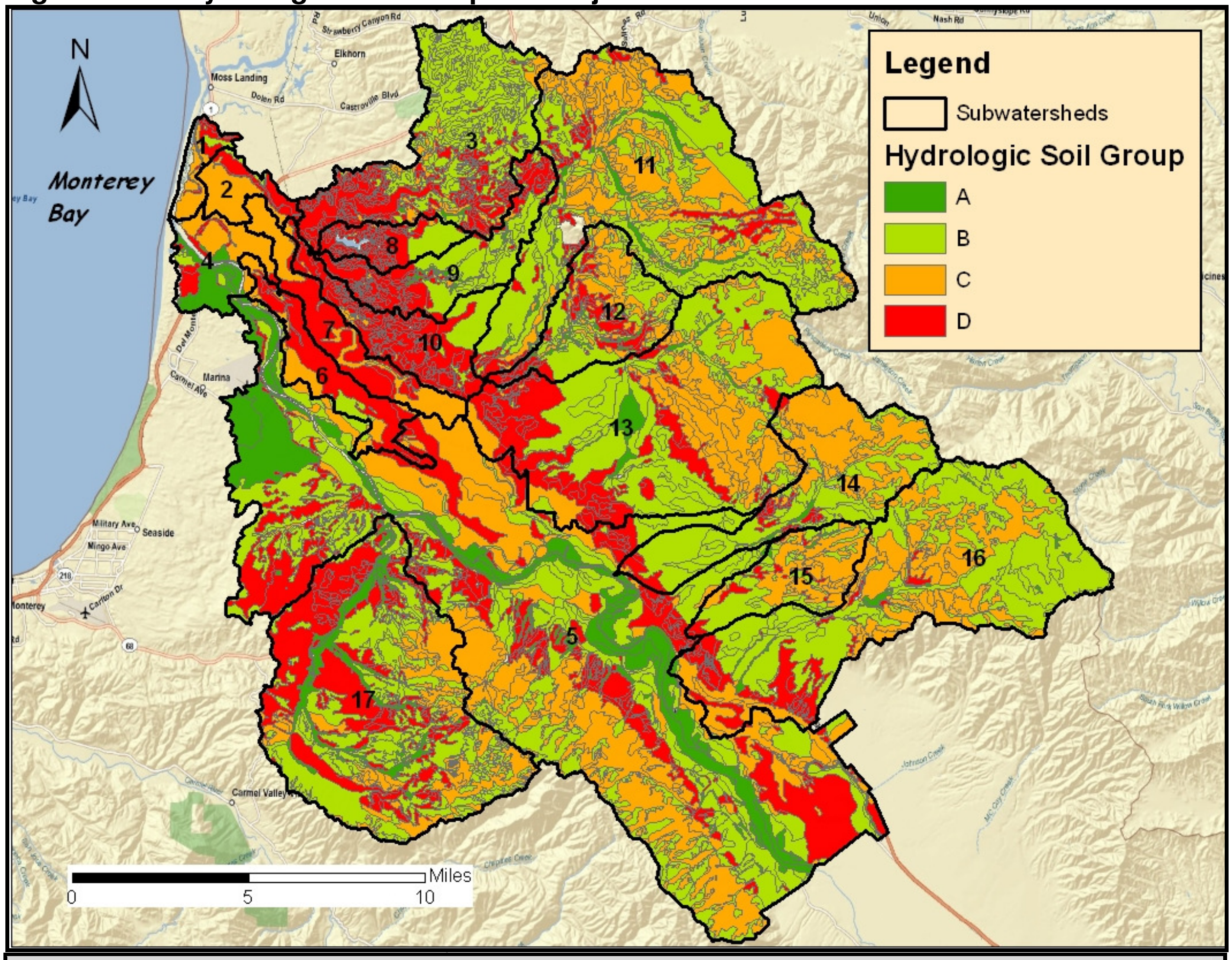
The relationship between nutrient export (loads) and soil texture is illustrated in Figure 6-13. Generally, fine-textured soils with lower capacity for infiltration of precipitation/water are more prone to runoff, and are consequently associated with a higher risk of nutrient loads to surface waters.

Figure 6-13. Median Annual Total N and Total P Export for Various Soil Textures.



The soil survey for Monterey County was compiled by the U.S. Department of Agriculture National Resources Conservation Service (NRCS) and is available online under the title of Soil Survey Geographic (SSURGO) Database. SSURGO has been updated with extensive soil attribute data, including Hydrologic Soil Groups. Hydrologic Soil Groups are a soil attribute associated with a mapped soil unit, which indicates the soil's infiltration rate and potential for runoff. Figure 6-14 shows the distribution of hydrologic soil groups in the Project Area along with a tabular description of the soil group's hydrologic properties.

Figure 6-14. Hydrologic Soil Groups in Project Area.



Hydrologic Soil Group Descriptions:	
A	Well-drained sand and gravel; high permeability
B	Moderate to well-drained; fine to moderately course texture; moderate permeability
C	Poor to moderately well-drained; moderately fine to fine texture; slow permeability
D	Poorly drained; clay soils, or shallow soils over nearly impervious layers(s)

Table 6-2. Distribution of Hydrologic Soil Groups by Watershed (% of watershed area).

Watershed	Hydrologic Soil Group (HSG)				Dominant HSG(s)
	A	B	C	D	
Old Salinas River	0%	8%	52%	40%	**C/D**
Tembladero Slough	0%	6%	61%	33%	**C**
Merritt Lake	1%	59%	7%	33%	**B**
Salinas River Lagoon	38%	5%	42%	15%	**A/C**
Salinas River	15%	35%	28%	22%	**B/C**

Watershed	Hydrologic Soil Group (HSG)				Dominant HSG(s)
Blanco Drain	0%	9%	26%	64%	**D**
Alisal Slough	0%	1%	46%	53%	**D**
Espinosa Slough	0%	29%	1%	70%	**D**
Santa Rita Creek	4%	47%	2%	47%	**B/D**
Reclamation Canal	0%	22%	4%	74%	**D**
Gabilan Creek	4%	48%	38%	10%	**B/C**
Natividad Creek	4%	41%	30%	25%	**B/C**
Alisal Creek	3%	43%	32%	23%	**B/C**
Quail Creek	1%	50%	42%	7%	**B/C**
Esperanza Creek	1%	40%	48%	10%	**B/C**
Chualar Creek	1%	57%	31%	11%	**B**
El Toro Creek	8%	39%	19%	34%	**B/D**

6.5 Geology

To comprehensively evaluate the effect of anthropogenic activities on nutrient loading, it is important to consider the potential impact on water quality in stream reaches draining natural environments and to consider the factors that control these natural, background loadings.

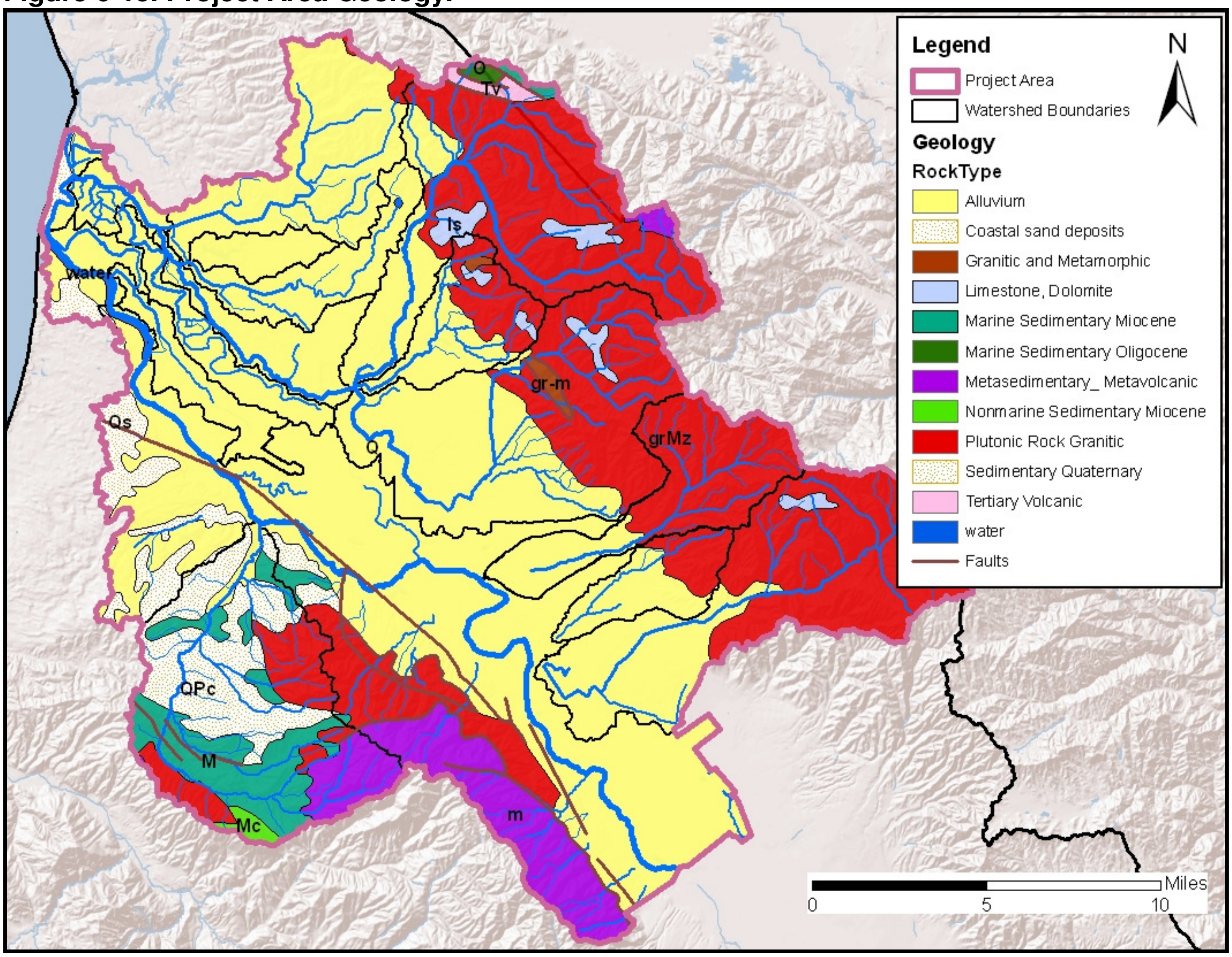
Geology may have a significant influence on natural, background concentrations of nutrients. Stein and Kyonga-Yoon (2007) report that catchment geology was the most influential environmental factor on variability in water quality from natural areas in undeveloped stream reaches located in Ventura, Los Angeles, and Orange counties, California. Stein and Kyonga-Yoon (2007) concluded that catchments underlain by sedimentary rock had higher stream flow concentrations of metals, nutrients, and total suspended solids, as compared to areas underlain by igneous rock. The mean annual average of nutrient concentrations (wet weather plus dry weather samples), as shown in Table 7 of Stein and Kyonga-Yoon (2007), indicates undeveloped stream reaches underlain by igneous rock had mean nutrient concentrations of: total nitrogen=1.12 mg/L, total phosphorus = 0.03 mg/L. Undeveloped stream reaches underlain by sedimentary rock in contrast had mean nutrient concentrations of: total nitrogen = 1.36 mg/L, total phosphorus = 0.06 mg/L.

It is important to note that while the aforementioned researchers stated that catchment geology can influence “nutrient” concentrations, in fact igneous and metamorphic geology are presumably likely to influence only phosphorus concentrations. In other words, phosphorus is a relatively common minor element in rock mineral assemblages; however nitrogen is not a trace element found in crystalline mineral assemblages. Nitrogen can however be associated with organic materials, which are commonly deposited with sedimentary material. In contrast, organic material is only an infrequent and trace component in some igneous or metamorphic rocks.

Digital data for California geology is available from the California Department of Conservation, Division of Mines and Geology. The digital database contains the geologic units and faults as shown on the Geologic Map of California by Charles W. Jennings published in 1977. The data is available via CD-ROM and may be obtained from California Department of Conservation, Division of Mines and Geology.

Figure 6-15 depicts the geology of the Project Area. For purposes of this display, the rock units tabulated and mapped in the original Jennings (1977) publication have been aggregated, to more broadly reflect generic rock type categories. Generally, headwater reaches in the Gabilan Range (northeastern side of Project Area) drain stream reaches underlain largely by granitic rock. In contrast, headwater reaches draining the Sierra De Salinas Range (southwestern side of Project Area) drain reaches that are underlain by a mix of sedimentary, igneous, metasedimentary and metavolcanic rocks.

Figure 6-15. Project Area Geology.



6.6 Permitted Point Sources

6.6.1 WWTF and Permitted Industrial Discharges

Untreated or treated (secondary treatment) discharges from wastewater point sources can be a significant source of anthropogenic nutrient loads to surface waters (USEPA, 1999).

The location of permitted industrial point sources in the project area are illustrated in Figure 6-16. Table 6-3 lists the permitted point sources within the project area.

Figure 6-16. Map of Permitted Point Sources in Project Area.

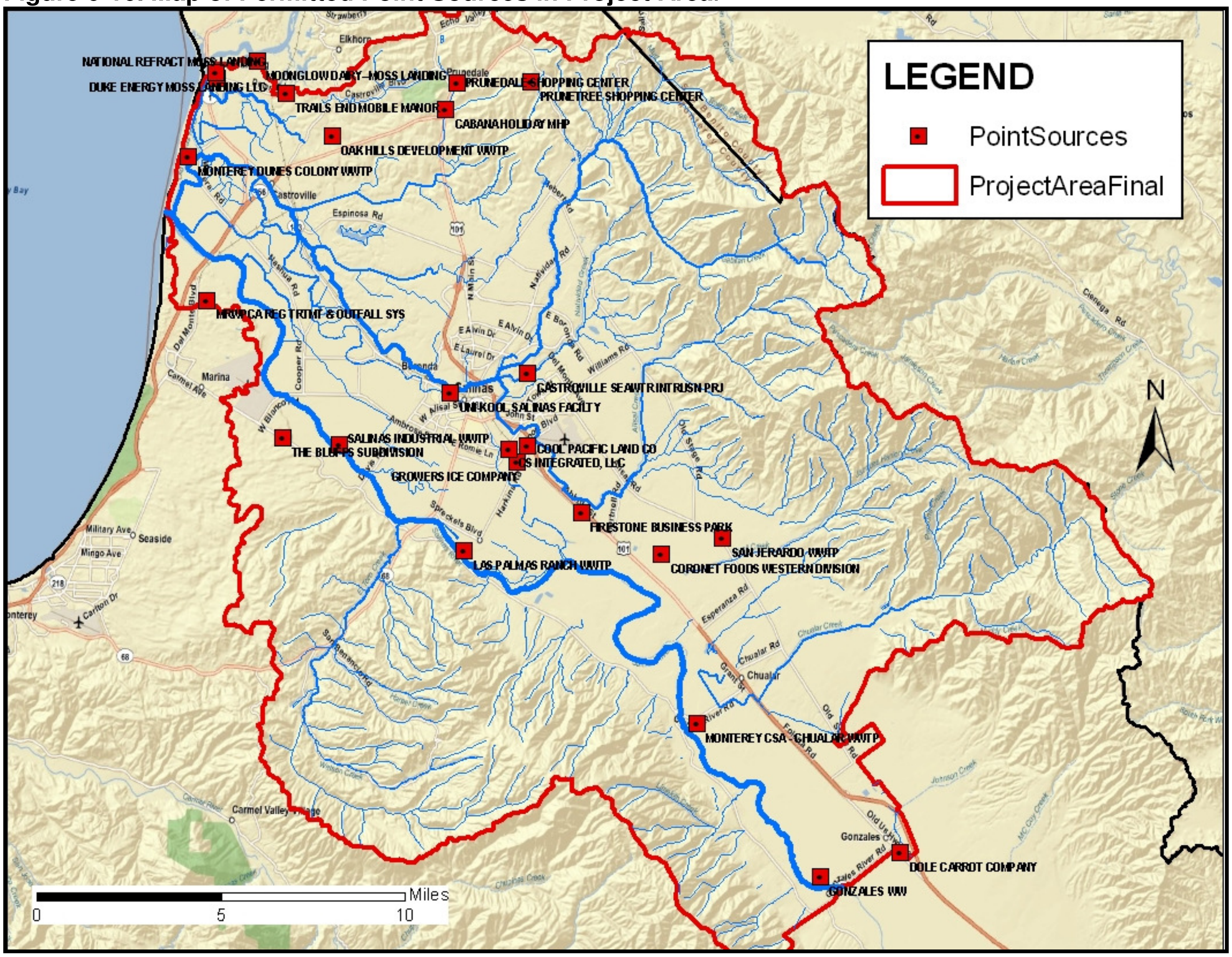


Table 6-3. Table of Permitted Point Sources in Project Area.

WDID	Facility	Order_	NPDES
3 270104001	GONZALES WW	01-039	
3 272008002	DOLE CARROT COMPANY	88-082	
3 270103001	MONTEREY CSA - CHUALAR WWTP	01-038	
3 275020001	CORONET FOODS WESTERN DIVISION	02-029	
3 271026001	LAS PALMAS RANCH WWTP	91-014	
3 271020001	SAN JERARDO WWTP	88-012	
3 271028001	FIRESTONE BUSINESS PARK	97-010WQ	

WDID	Facility	Order_	NPDES
3 271042001	GROWERS ICE COMPANY	01-016	CA0008069
3 272021001	CS INTEGRATED, LLC	01-119	CAG993001
3 270101003	COOL PACIFIC LAND CO	01-119	CAG993001
3 270111003	SALINAS INDUSTRIAL WWTP	97-039	CA0048101
3 271015001	THE BLUFFS SUBDIVISION	89-029	
3 272016001	UNI-KOOL SALINAS FACILTY	01-119	CAG993001
3 270201001	CASTROVILLE SEAWTR INTRUSN PRJ	94-101	
3 270118002	MRWPCA REG TRTMT & OUTFALL SYS	94-082	CA0048551
3 271011001	MONTEREY DUNES COLONY WWTP	87-175	
3 271007001	OAK HILLS DEVELOPMENT WWTP	01-009	
3 271003001	CABANA HOLIDAY MHP	86-029	
3 271041001	TRAILS END MOBILE MANOR	95-078	
3 271027001	PRUNEDALE SHOPPING CENTER	86-007	
3 271031001	PRUNETREE SHOPPING CENTER	87-146	
3 272006001	NATIONAL REFRACT MOSS LANDING	01-030	CA0007005
3 272011001	DUKE ENERGY MOSS LANDING LLC	00-041	CA0006254
3 275001001	MOONGLOW DAIRY--MOSS LANDING	01-033	

6.6.2 Caltrans Storm Water Loads

Pollutants generated by CalTrans facilities (highways, freeways maintenance facilities) have been considered by Regional Boards to be covered under the Caltrans statewide NPDES permit, and thus subject to a potential waste load allocation (point source). The Caltrans NPDES permit covers all statewide storm water discharges from their facilities and activities. The estimated annual average loads from Caltrans facilities in a hydrologic unit can be estimated for initial screening purposes using the Caltrans Water Quality Planning Tool, located at:

http://www.water-programs.com/wqpt.htm

These loads are for preliminary planning purposes and are not appropriate for developing allocations in TMDLs. The loads are from impervious surfaces only. The possible mitigating effects of unpaved areas along highways right-of-ways resulting from processes like evapo-transpiration, sedimentation, infiltration are not considered in calculating the loads.

Caltrans facilities in the lower Salinas River watershed are shown below, with **initial screening level estimates** of annual storm water loads.

Hydrologic Subarea	Caltrans Facilities			Caltrans Annual Loads (Kg/year)	
	Maintenance Stations	Freeways and Highways	Length (miles)	Total N	Total P
309.1 Lower Salinas Valley	850 Elvee Drive, Salinas	Route 1	6.2	915	84
		Route 68	7.5		
		Route 101	11.7		
		Route 156	1.4		
		Route 183	10		
309.12 Lower Salinas Valley (Moro Cojo)	none	Route 1	0.9	127	11
		Route 156	4.3		
			TOTAL	**1042**	**95**

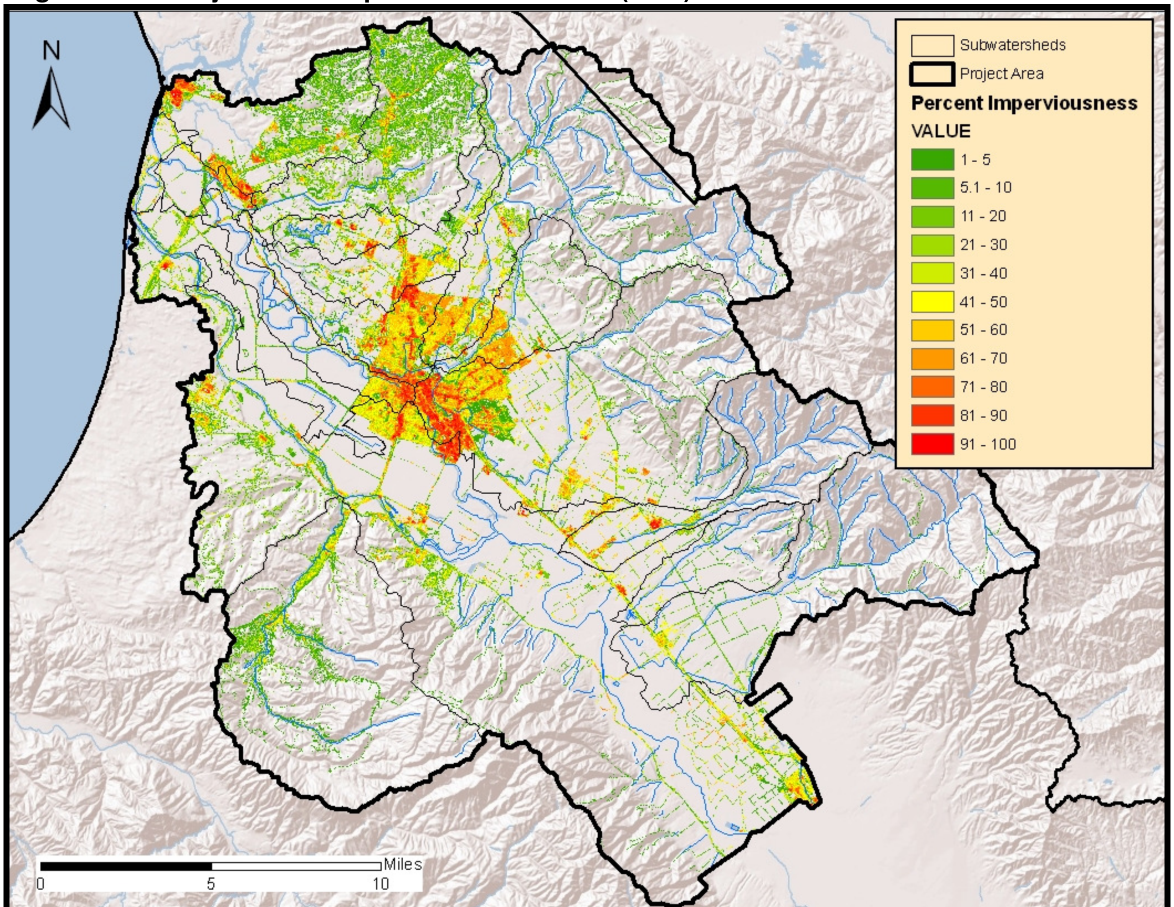
6.7 Urban Sources

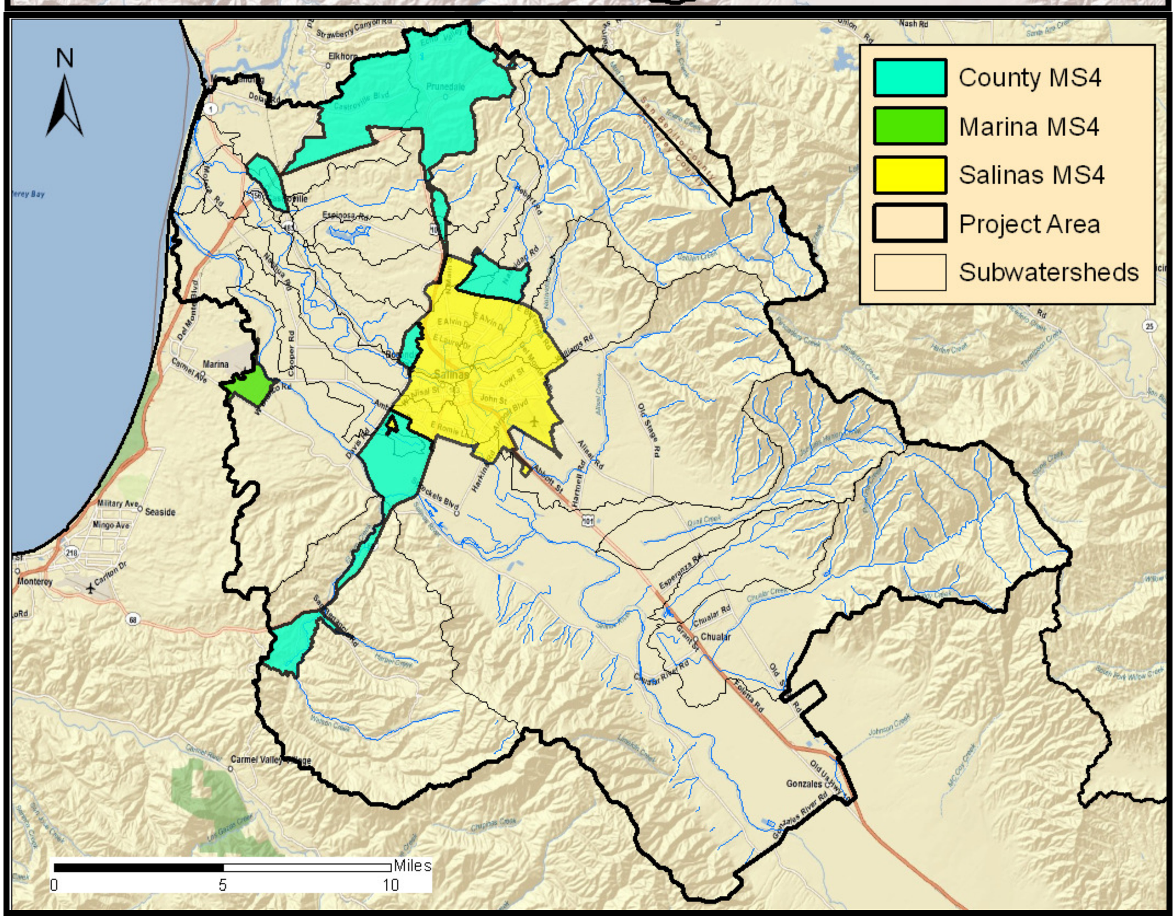
6.7.1 Impervious Cover

Urbanization and associated impervious cover has been widely demonstrated to increase the amount and types of pollutants carried into lakes, streams, and rivers. Impervious cover refers to roads, parking lots, driveways, asphalt, and any surface cover that precludes the infiltration of water into the soil. Pollutants deposited on impervious surface have the potential of being entrained by discharges of water from storm flows, wash water, or excess lawn irrigation, etc. and routed to storm sewers, and potentially being discharged to surface water bodies.

Impervious cover data are available from the National Land Cover Database (NLCD, 2001). Refer NLCD provides per-pixel estimates of imperviousness (percent impervious cover) as derived from satellite imagery. Figure 6-17 illustrates the distribution and percent imperviousness in the Project Area and the municipal separate storm sewer system (MS4) permit boundaries.

Figure 6-17. Project Area Impervious Cover and (MS4) Permit Boundaries.





6.7.2 Urban Stormwater Data

There is only limited, site-specific pollutant concentration data available on urban stormwater runoff in the project area. National and regional urban stormwater data are also available from the National Stormwater Quality Database (NSQD). NSQD collects and evaluates stormwater data from a representative number of NPDES (National Pollutant Discharge Elimination System) MS4 (municipal separate storm sewer system) stormwater permit holders. The monitoring data collected over nearly a ten-year period from more than 200 municipalities throughout the country reportedly have a great potential in characterizing the quality of stormwater runoff and comparing it against historical benchmarks.

The NSQD data is available at:

http://rpitt.eng.ua.edu/Research/ms4/Paper/recentpaper.htm

A spreadsheet of NSQD, that was current as of summer 2009, is embedded below:

S:\TMDLs & Watershed Assessme

A summary of available stormwater data for nutrients included in NSQD, version 1.1 is shown below:

	NH3 (mg/L)	N02+NO3 (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	Phos., filtered (mg/L)	Phos., total (mg/L)
Overall Summary (3765)					
Number of observations	1909	3076	3192	2477	3285
% of samples above detection	71.7	97.3	95.6	85.1	96.6
Median	0.44	0.6	1.4	0.13	0.27
Coefficient of variation	1.4	1.1	1.3	1.6	1.5

6.8 Agricultural Cropland Sources (Fertilizer)

6.8.1 Crop Cover

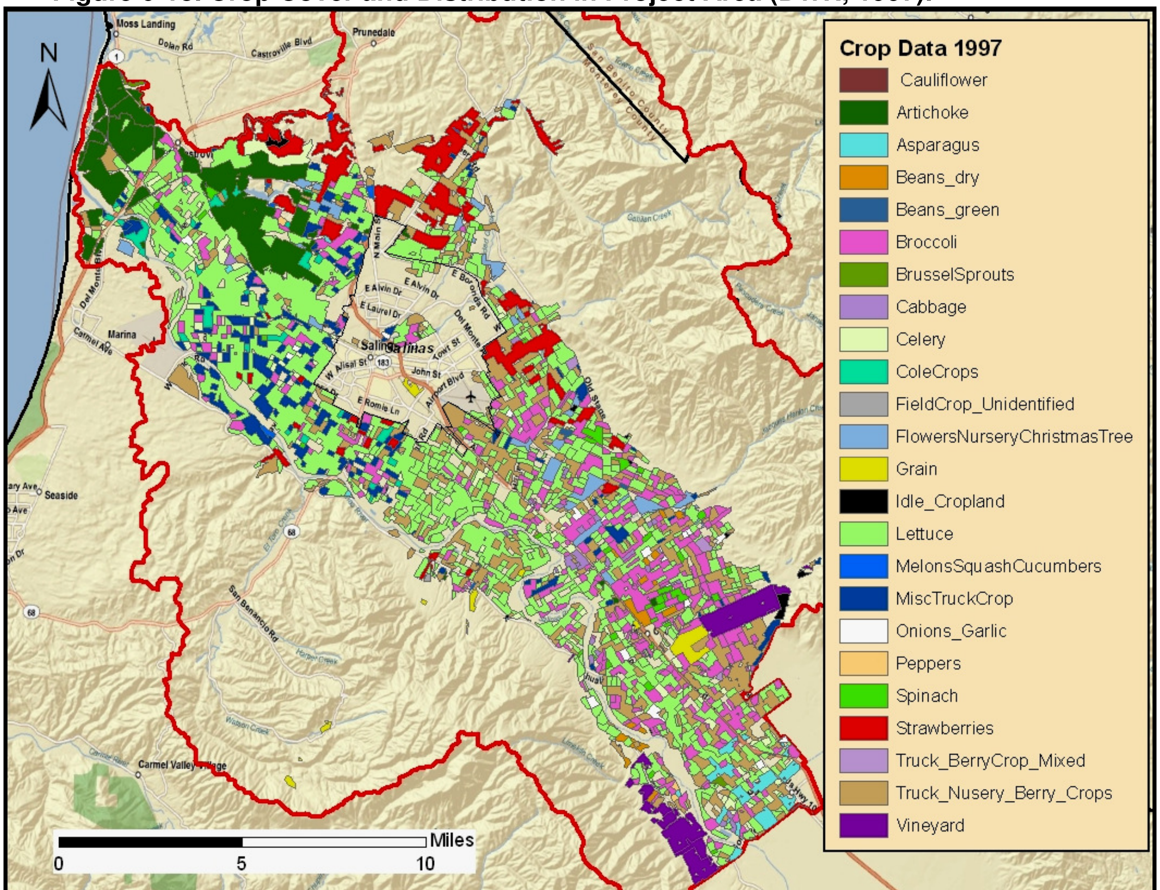
The estimated magnitude of nutrient loads from agricultural lands may vary substantially based on crop type (Harmel et al., 2006). Nutrient loads refer to the amount of nitrogen or phosphorus exported from an area or specific land use over a specific time period (e.g., typically, kilograms per hectare per year). Harmel et al. (2006) report nutrient loading values that range from a national median of 21.9 kg/ha nitrogen for soybean crop, to a national median of 3.02 kg/ha nitrogen for sorghum. Therefore, it is important to assess to the degree possible, local agricultural conditions in order to gage the level of risk of nutrient loading to surface water from these sources.

The California Department of Water Resources (DWR) has compiled digitized crop data for Monterey County, which can be used to create crop maps in the Project Area, as shown in Figure 6-18. The digital crop data can be downloaded from

http://www.water.ca.gov/landwateruse/lusrvymain.cfm

The most recent version of DWR's Monterey County crop maps is 1997. Although the vintage of this data is not current, it can broadly be used to illustrate the general crop types and cropping patterns in the Project Area. The DWR data indicates that the most common Project Area crop types are lettuce, broccoli, other cole crops, truck and berry crops, artichoke, strawberry, commercial nurseries and vineyard. This is consistent with more recent crop reporting (i.e., the 2008 Monterey County Agricultural Commissioner's Crop Report), which indicates that lettuce, broccoli, cole crops, and nursery products are among the major crops of the County.

Figure 6-18. Crop Cover and Distribution in Project Area (DWR, 1997).



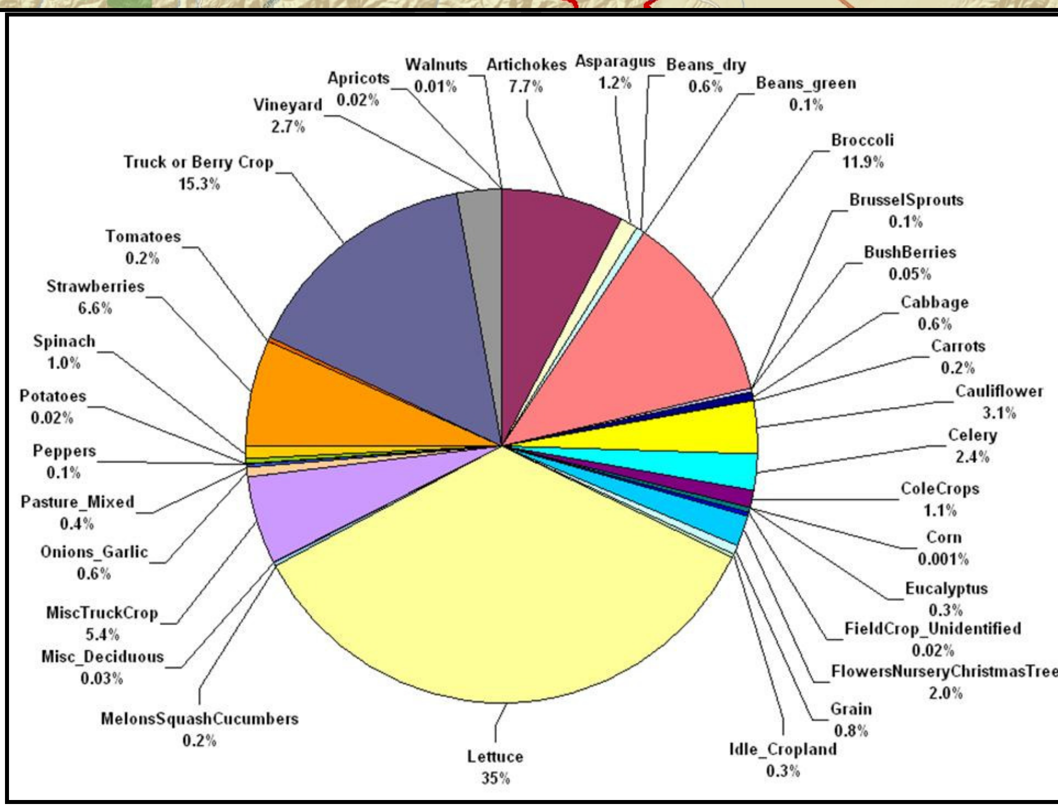


Figure 6-19. Pie chart of Crop Cover in Project Area (source: DWR, 1997).

6.8.2 Commercial Nurseries/Greenhouses

Plants that are grown in intensive, out-of-ground container-nursery and greenhouse operations may potentially constitute a significant source of nutrient loading to surface waters. Water that is applied through overhead or drip irrigation systems may either fall between, and/or leach from the container, and may contribute to non-point source nutrient runoff (see USEPA Nurseries and Greenhouses Website http://www.epa.gov/oecaagct/nurgreen.html).

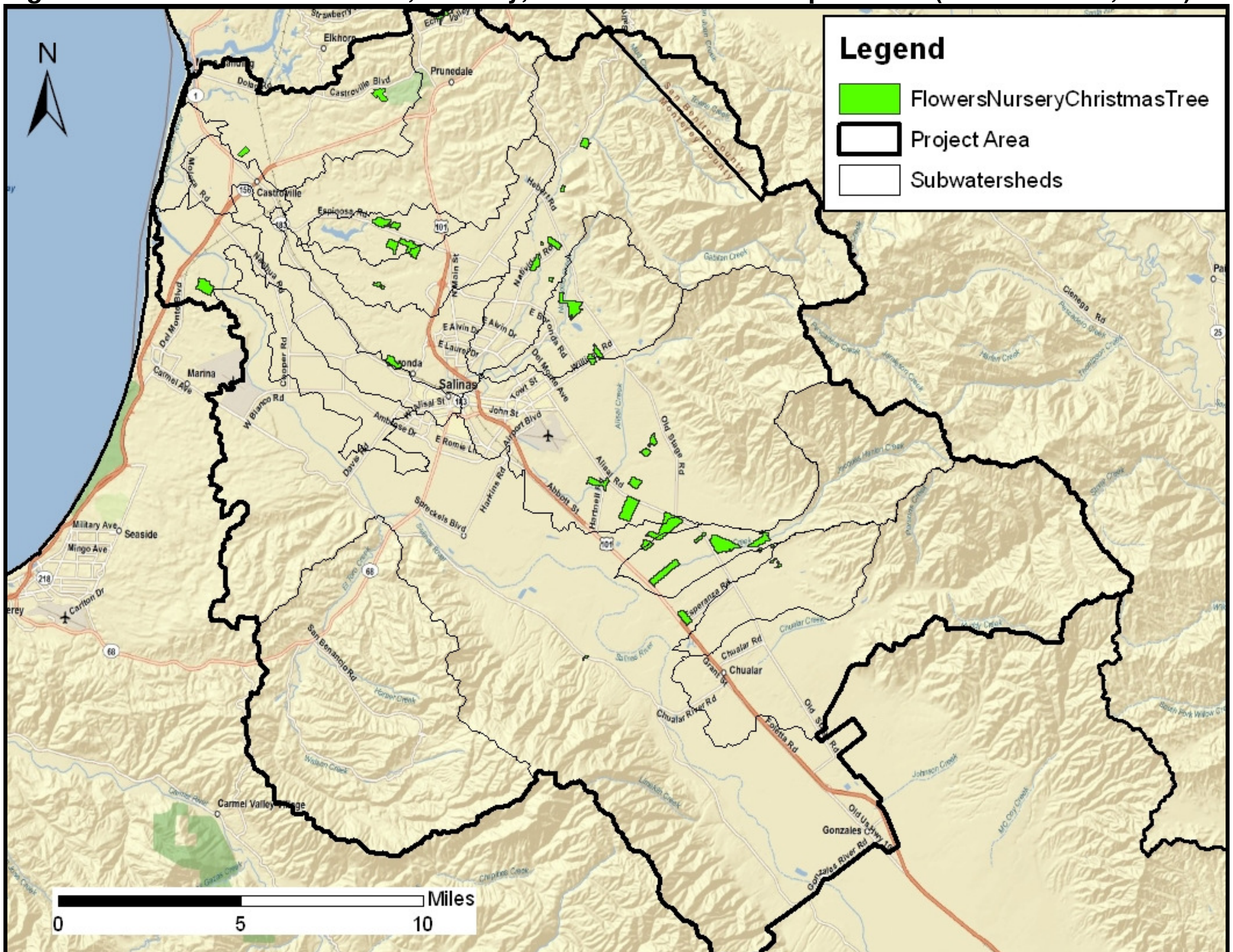
> *"Nurseries and greenhouses are classified in North American Industry Classification System (NAICS) Code 111 (Crop Production). Nurseries have and Greenhouse are grouped under NAICS Code 1114. NAICS has replaced the U.S. Standard Industrial Classification (SIC) system. According to Dun and Bradstreet, an estimated 88,000 U.S. establishments were listed under SIC code 01 in 1996. These businesses are in a separate category on this Web site because their practices differ considerably from those of field crop production."*
>
> -- from: USEPA, http://www.epa.gov/oecaagct/nurgreen.html

The California Department of Water Resources (DWR) has compiled digitized crop data for Monterey County, which can be used to create maps of commercial nursery and flower operations in the Project Area, as shown in Figure 6-20. The digital crop data can be downloaded from:

http://www.water.ca.gov/landwateruse/lusrvymain.cfm

The most recent version of DWR's Monterey County crop maps is 1997. Although the vintage of this data is not current, it can broadly be used to illustrate the location of current or recent historical commercial nursery and flower operations in the Project Area.

Figure 6-20. Commercial Flower, Nursery, and Christmas Tree Operations (Source: DWR, 1997)



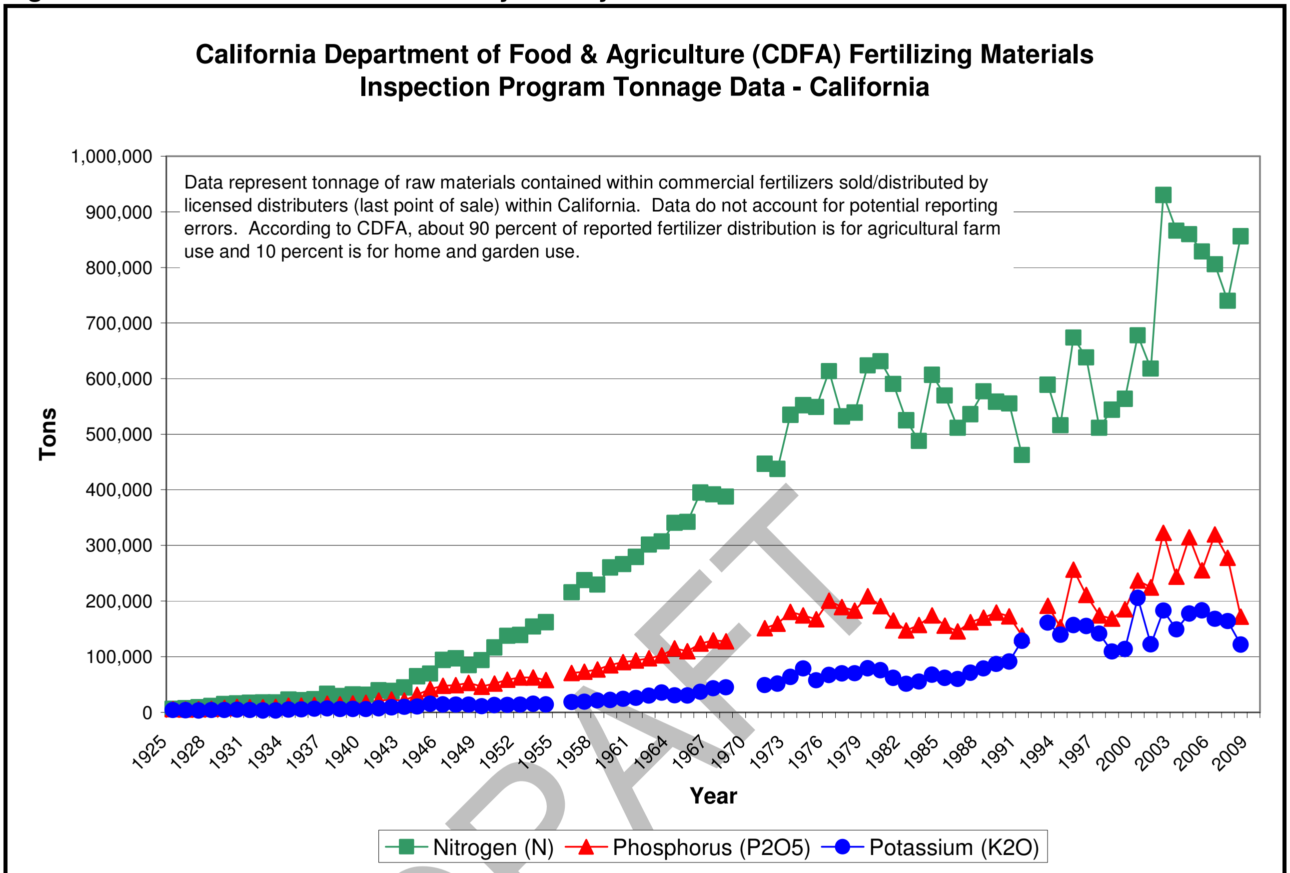
6.8.3 Fertilizer Sales and Applications

Fertilizer sales data, at the County level, is available from the California Department of Food and Agriculture (CDFA), Fertilizing Materials Inspection Program Tonnage Reports. The tonnage reports aren't published on line, but can be ordered as PDF files. Staff was able to receive PDFs of tonnage reports from Christina Mullens at CDFA. Ms. Mullens email contact is:

CMullens@cdfa.ca.gov

Figure 6-21 illustrates temporal trends of fertilizer sales in Monterey County. It is important to recognize that fertilizer sales in a county does not necessarily mean those fertilizers were actually applied in that same county. Recorded sales in one county may actually be applied on crops in other, nearby counties. However, Krauter et al. (2002) reported fertilizer application estimates that were obtained from surveys, county farm advisors and crop specialists; these data indicated that in the Central Coast region, county fertilizer recorded sales correlated well with estimated in-county fertilizer applications (within 10 percent).

Figure 6-21. Fertilizer Sales in Monterey County.



California fertilizer application rates on specific crop types are available from the U.S. Department of Agriculture, National Agricultural Statistics Service, as shown in Table 6-4 and Figure 6-22.

Table 6-4. California Fertilizer Application Rates.

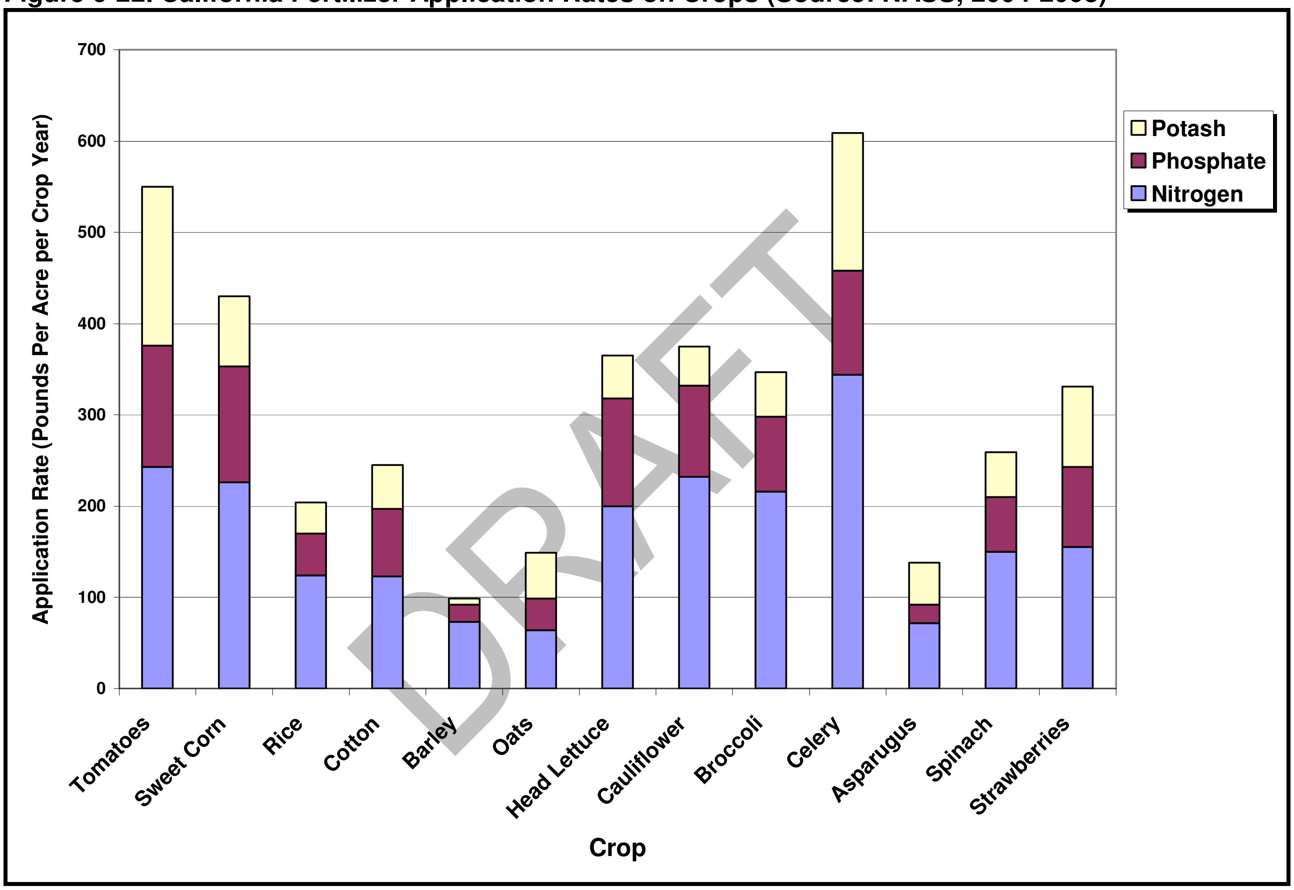
Crop	Application Rate per Crop Year (pounds per acre) in California			Source
	Nitrogen	Phosphate	Potash	
Tomatoes	243	133	174	2007 NASS report
Sweet Corn	226	127	77	2007 NASS report
Rice	124	46	34	2007 NASS report
Cotton	123	74	48	2008 NASS report
Barley	73	19	7	2004 NASS report
Oats[1]	64	35	50	2006 NASS report
Head Lettuce	200	118	47	2007 NASS report
Cauliflower	232	100	43	2007 NASS report
Broccoli	216	82	49	2007 NASS report

	Application Rate per Crop Year (pounds per acre) in California			
Celery	344	114	151	2007 NASS report
Asparagus	72	20	46	2007 NASS report
Spinach	150	60	49	2007 NASS report
Strawberries[2]	155	88	88	University of Delaware Ag, Nutrient Recommendations on Crops webpage

[1]insufficient reports to publish fertilizer data for P and potash; used national average from 2006 NASS report for P and K

[2] median of ranges, calculated from table 1, table 4, and table 5 @ http://ag.udel.edu/other_websites/DSTP/Orchard.htm

Figure 6-22. California Fertilizer Application Rates on Crops (Source: NASS, 2004-2008)



It is important to note that the aforementioned recorded County fertilizer sales also include a residential use/urban component (see Figure 6-21), which would be consequently characterized as a potential urban source of nutrients.

6.9 Animal Agriculture

6.9.1 Confined Animal Operations

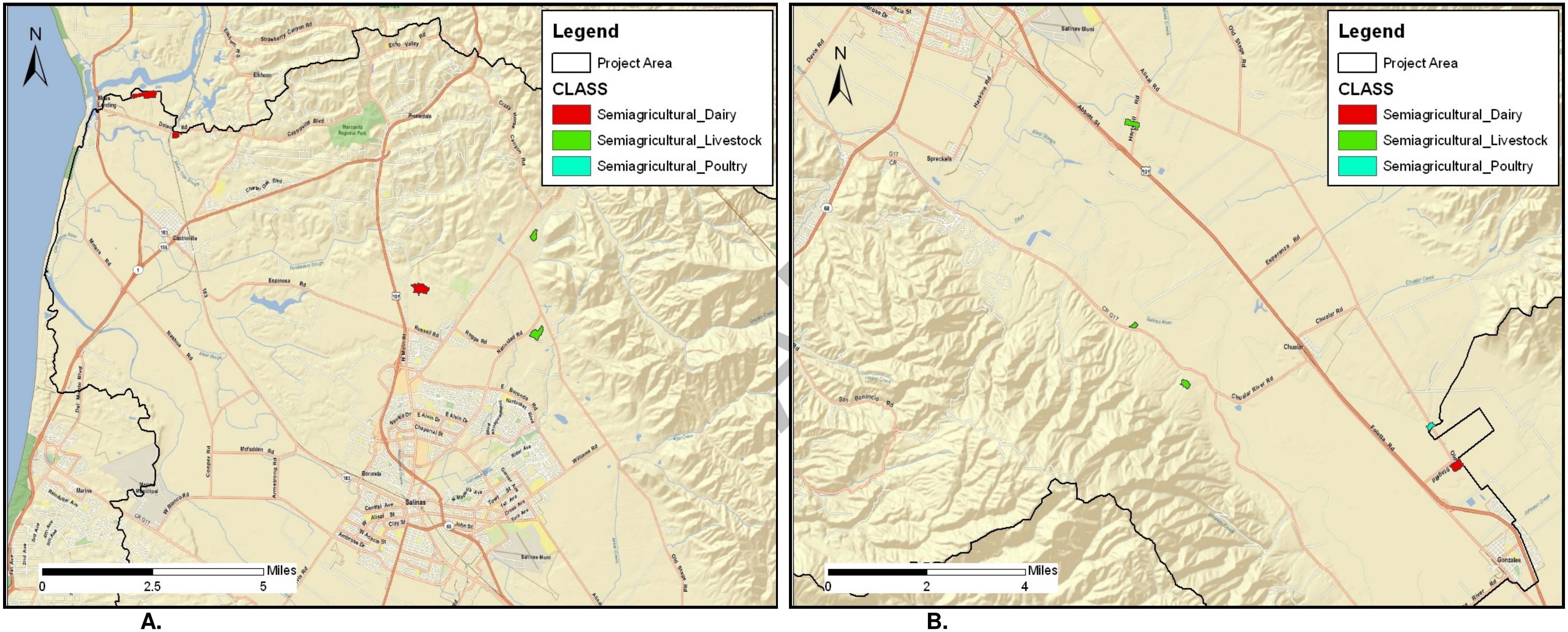
Animal waste associated with confined animal operations (feedlots, dairies, etc.) can constitute a potential source of nutrient loads to surface waters. The California Department of Water Resources (DWR) has compiled digitized crop data for Monterey

County, which can be used to create maps of confined animal operations in the Project Area, as shown in Figure 6-23. The digital DWR crop data can be downloaded from:

http://www.water.ca.gov/landwateruse/lusrvymain.cfm

The most recent version of DWR's Monterey County crop maps is 1997. Although the vintage of this data is not current, it can broadly be used to illustrate the location of current or recent historical confined animal operations in the Project Area. The 1997 DWR data indicate there are (or were) several dairies and confined livestock facilities in the project area, as well as one poultry facility (see Figure 6-5). At present, to the best of staff's knowledge there is currently only one confined animal facility that operates under a Water Board permit in the project area: the Moon Glow dairy located in the Moro Cojo Slough subwatershed.

Figure 6-23. Confined Animal Operations in northern Project Area (A) and southern Project Area (B). (Source: DWR, 1997).



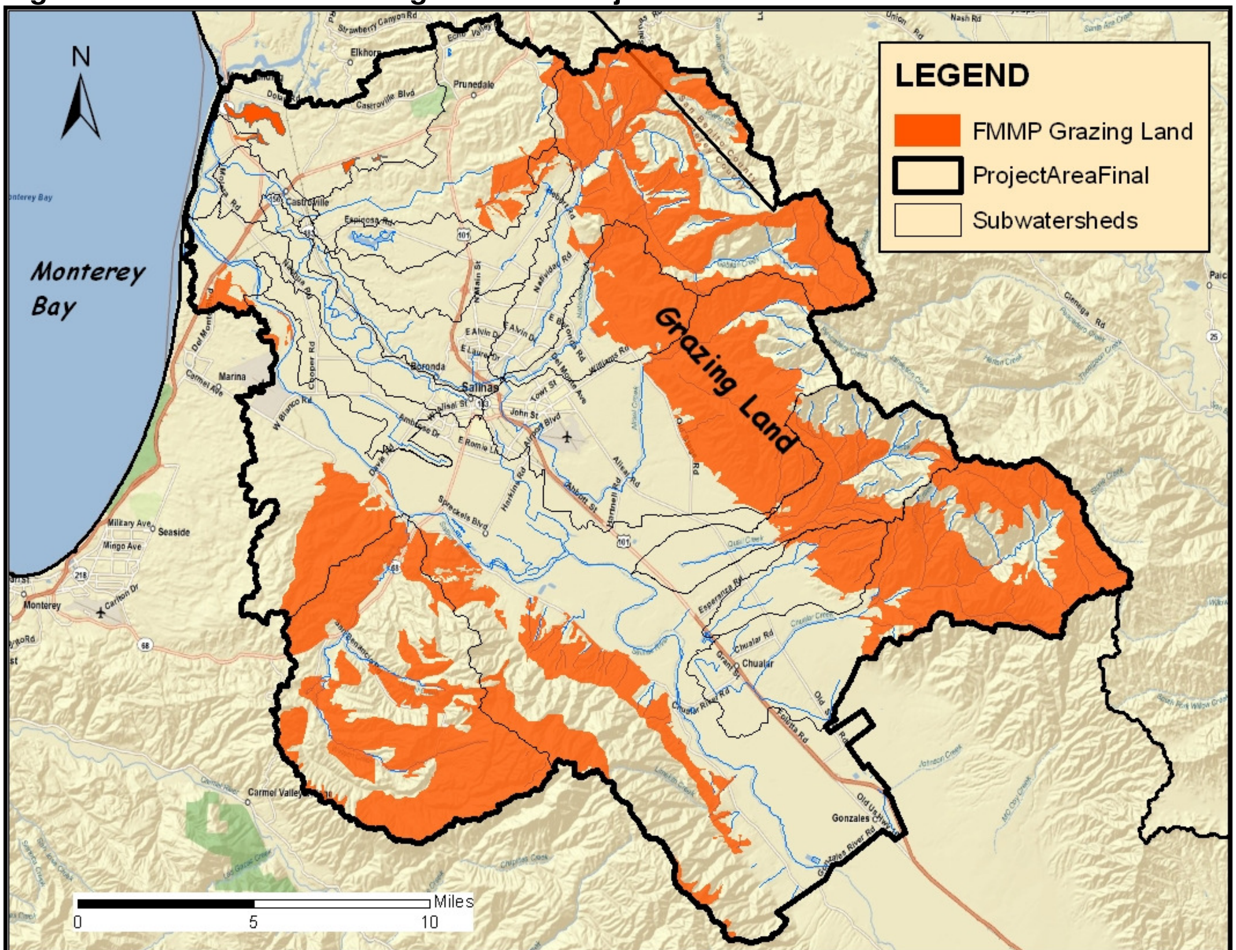
6.9.2 ***Grazing Operations***

Livestock grazing on rangelands, pasture, or that are managed in confined animal facilities can be a source of nutrient (i.e., nitrogen and phosphorous) pollution in streams. Livestock that are managed in confined facilities, like feed lots and dairies, can be considered a point source of pollution, as large quantities of manure may be concentrated in one area. Domestic animals that roam freely on pasture or grazing land generate significant amounts of nutrient waste on the landscape, and may represent a diffuse, nonpoint source of pollution.

Nutrients from domestic animal waste can be discharged to a stream by either direct deposition (defecation or urination) or by overland transport during a runoff event. Valigura et al. (2001) report that in the Pacific region of the United States, non-agricultural sources of nutrients can be highly associated with rangelands which constitute a major land use throughout much of the Pacific region.

The amount and distribution of grazing land in the Project Area can be estimated from digital land use datasets available from the California Department of Conservation Farmland Mapping and Monitoring Program (FMMP). FMMP classifies grazing land as *"land on which the existing vegetation is suited to the grazing of livestock.".* The FMMP grazing land dataset was developed in cooperation with the California Cattlemen's Association and the University of California Cooperative Extension. Figure 6-24 shows the distribution and extent of grazing land in the Project Area.

Figure 6-24. Extent of Grazing Lands in Project Area.



6.9.3 Livestock Inventory

If necessary and appropriate, staff may estimate nutrient loading from livestock by compiling population estimates and nutrient loads by each animal type in the project area. Table 6-5 summarizes the inventory of major producers of fecal coliform in the project area. It is important to recognize there is uncertainty in these numbers; they are estimates based on census surveys. Livestock numbers are taken from the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service Census database. The USDA database tabulate the number of livestock reported in Monterey County. At the time this project report was written, the most recent version of the USDA Agricultural Census available online was for 2007.

Table 6-5. Monterey County Livestock Inventory.

Livestock	Number	Source
Cattle and calves	57346	USDA-NASS, 2007
Hogs and pigs	197	USDA-NASS, 2007
Goats	1166	USDA-NASS, 2007

Livestock	Number	Source
Sheep and Lambs	1918	USDA-NASS, 2002
Poultry (layers)	3936	USDA-NASS, 2007
Poultry (broilers)	49	USDA-NASS, 2007
Poultry (turkey)	73	USDA-NASS, 2007
Alpacas	227	USDA-NASS, 2007
Llamas	33	USDA-NASS, 2007
Mules and Donkeys	55	USDA-NASS, 2007
Rabbits	550	USDA-NASS, 2007
Horses		Can estimated from the American Veterinary Medical Association's U.S. Pet Ownership and Demographics Sourcebook (AMVA, 2007),

Using the above Monterey County survey estimates, livestock numbers (stocking density) in project area subwatersheds may be derived using a USEPA-recognized estimation method, which includes using U.S. Department of Agriculture county data on livestock, and land use information (USEPA, 2001) – see Figure 6-26.

Per the USEPA-recognized methodology, it is assumed that livestock are evenly distributed throughout all rangeland/pasture/grassland in the county. To obtain an average animal geographic stocking density (animal units per acre), the number of livestock in Monterey County were obtained from the USDA Agricultural Census database, and can divided by the amount of rangeland/pasture in Monterey County. This will yield an average county-wide animal stocking density. This average density/acre value can then be multiplied by the acreage of rangeland/pasture/grassland in the project area, and also by the acreage amounts among the various subwatersheds.

Figure 6-25. USEPA Livestock Stocking Density Estimation Method.

USEPA Pathogen TMDL Guidance:
Estimation Method for Number of Grazing Cows in a Watershed

Laurel River watershed contains areas in Gunston and Putnam counties. A major potential source of bacteria loading within the watershed is grazing livestock, primarily cattle. Data from the 1997 USDA Census of Agriculture provided numbers of livestock in each county covering portions of the watersheds, as well as total pastureland within each county. The livestock counts and pasture areas were used to determine livestock densities (e.g., number of cows per acre of pastureland) for each county, assuming livestock are evenly distributed over pasture area in the county.

The area of pastureland in each subwatershed and within each county was determined using GIS data layers. The pasture area of the subwatershed within each county and the livestock density for the counties were used to calculate the livestock counts within the portion of the subwatershed intersecting that county. That is to say, each county has a unique livestock density that was applied to the portion of the subwatershed within that county. The county/subwatershed livestock estimates were then summed to determine livestock counts for the entire subwatershed. The following example presents the calculation of beef cattle grazing in the West Fork 1 subwatershed of the Laurel River watershed. The county densities for beef cattle are

$$\text{Gunston County density} \bullet \frac{2{,}850 \text{ beef cows}}{16{,}485 \text{ acres pastureland}} \bullet 0.17 \frac{\text{beef cows}}{\text{acre of pastureland}}$$

$$\text{Putnam County density} \bullet \frac{6{,}376 \text{ beef cows}}{19{,}811 \text{ acres pastureland}} \bullet 0.32 \frac{\text{beef cows}}{\text{acre of pastureland}}$$

The West Laurel 1 subwatershed of the Laurel River watershed has 37 acres of pastureland in Gunston County and 172 acres of pastureland in Putnam County. Therefore, the total number of beef cows in the West Laurel 1 subwatershed is

$$\left(37 \text{ acres} \times 0.17 \frac{\text{cows}}{\text{acre}}\right) \bullet \left(172 \text{ acres} \times 0.32 \frac{\text{cow}}{\text{acre}}\right) \bullet 61 \text{ beef cows}$$

From: USEPA (2001), Protocol for Developing Pathogen TMDLs (EPA 841-R-00-002)

6.9.4 Manure

The amount of nutrient loading from domestic animal waste can be estimated using data available from the USGS. USGS provides County-based estimates of nitrogen and phosphorus content of animal manure in the United States. The data is available at:

http://water.usgs.gov/GIS/metadata/usgswrd/XML/manure.xml

This data set contains county estimates of nitrogen and phosphorus content of animal wastes produced annually for the years 1982, 1987, and 1992. The estimates are based on animal populations for those years from the 1992 Census of Agriculture (U.S. Bureau of the Census, 1995) and methods for estimating the nutrient content of manure from the Soil Conservation Service (1992).

According to the 1992 USGS livestock manure estimates, Monterey County ranked 21st out of all California counties in the intensity (kg/ha/year) of nitrogen discharge from livestock waste – see Figure 6-26.

Figure 6-27 shows maps that illustrate the annual nitrogen and phosphorus production (kg/ha/year) from livestock waste at the county-level throughout the State. In Monterey County, annual Nitrogen discharge from domestic animals was 5.92kg/ha/year, and 1.66 kg/ha/year for phosphorus.

It is important to emphasize again that these manure estimates are based on older vintage Census of Agriculture surveys. The most recent Census of Agriculture survey available from the US Department of Agriculture is for 2007. These older vintage manure data may be appropriate for screening level analysis; however, it may be prudent to verify that the 2007 Census of Agriculture estimates for livestock are not substantially or grossly outside the range from the older vintage surveys used in the USGS manure estimates.

Figure 6-26. Livestock Manure Discharged (Annual - 1992) in California Counties

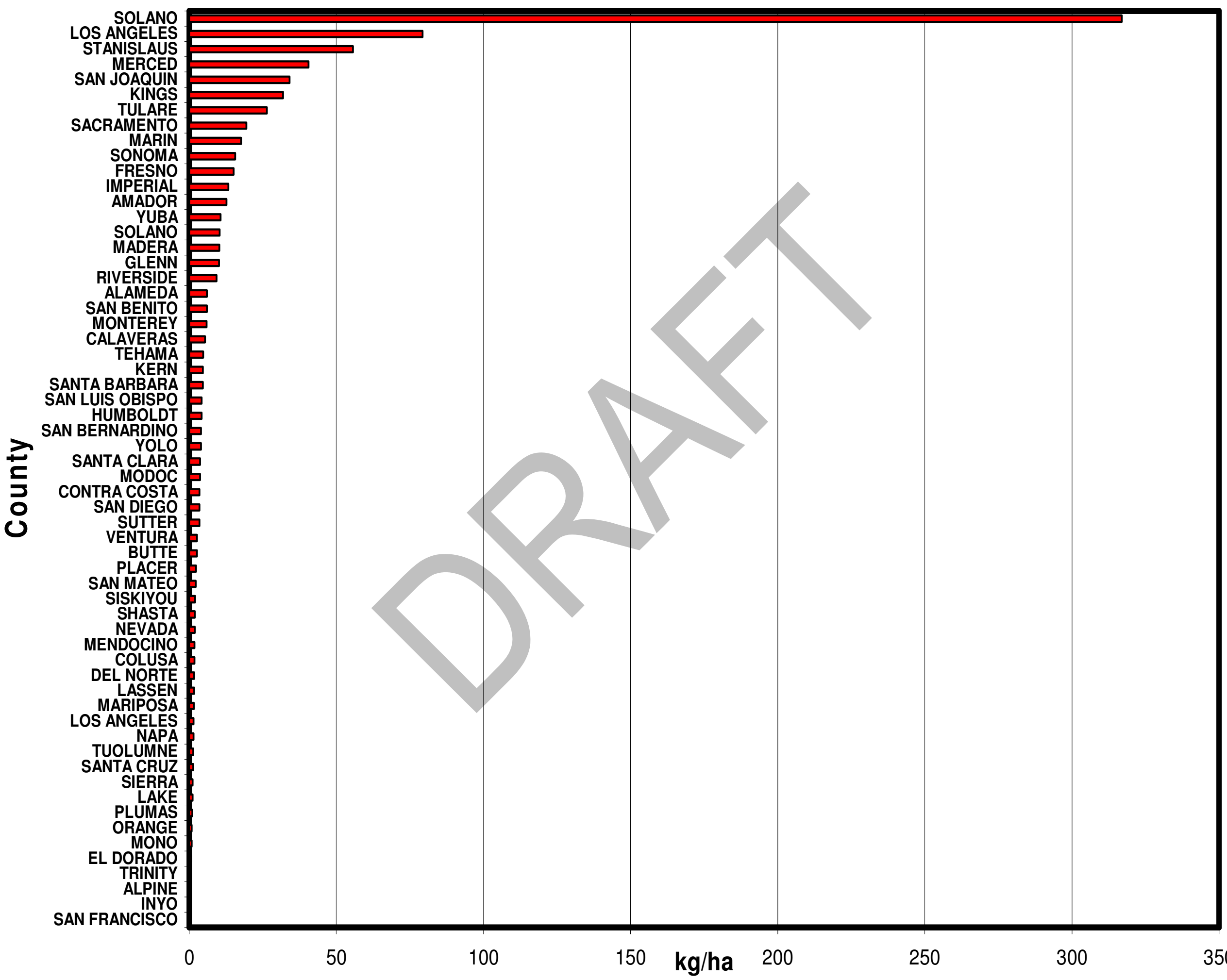
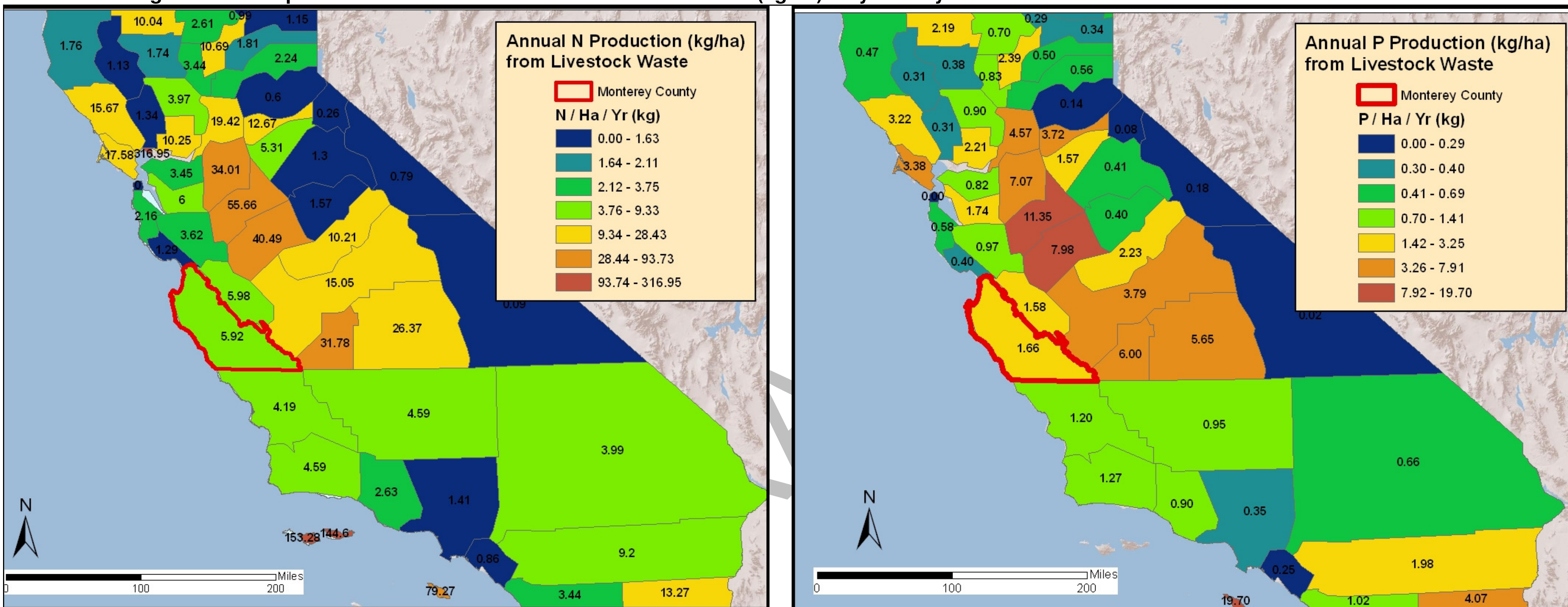


Figure 6-27. Map of Annual Load of Livestock Waste as N and P (kg/ha) – by County.



USGS SPARROW modeling have previously estimated the nutrient flux into the Salinas and Reclamation Canal watersheds from manure sources, as well as from fertilizer, atmospheric deposition, and non-agricultural fertilizer sources. The data can be found here:

http://water.usgs.gov/nawqa/sparrow/wrr97/results.html

6.10 Groundwater (Baseflow)

Baseflow can potentially contribute significant nutrient loads to surface waters. Embedded below are compiled sources of regional data on shallow groundwater nutrient concentrations.

S:\TMDLs & Watershed Assessme	S:\TMDLs & Watershed Assessme	S:\TMDLs & Watershed Assessme

6.11 Atmospheric Deposition

Atmospheric deposition can significantly contribute nutrients to surface waters. . Because of the atmospheric linkages of the N cycle and industrial additions of N to the atmosphere, N loading from atmospheric deposition can potentially be significant. As reported by Reckhow (1980), atmospheric inputs consist of two major components: 1) wind transported material, commonly called dustfall, removed from the air by sedimentation or impaction; and 2) soluble gases or salts which are scavenged by rainfall. Direct atmospheric deposition is not considered to be a controllable source.

In contrast, atmospheric deposition of P is generally very small. Ahl (1988) cited atmospheric deposition of 0.05–0.5 kg P/ha/yr in Canada. Annual P loading rates to the Chesapeake Basin have been estimated at 0.16 to 0.47 kg/ha (Wang et al., 1997). A similar P deposition rate of 0.16 kg/ha/yr has been measured in the Lake Champlain basin (VTDEC and NYS DEC, 1997). An estimated annual load of 0.66 kg P/ha by atmospheric deposition has been cited for the Albemarle-Pamlico Basin (McMahon and Woodside, 1997).

It is important to note that atmospheric deposition of nutrients is typically more significant in lakes and reservoirs, than in in creeks or streams. This is because the surface area of a stream is typically small compared to the area of a watershed; consequently atmospheric deposition may contribute relatively little in the way of nutrient loads to the project waterbodies.

Sources for estimating atmospheric nutrient deposition (mass per unit area) are given below:

Table 5.20: Annual wet and dry atmospheric deposition for Carpinteria, Franklin, and Santa Monica creek watersheds in moles per hectare.

Nutrient Atmospheric Deposition	Carpinteria (mol ha^{-1})	Franklin (mol ha^{-1})	Santa Monica (mol ha^{-1})
NO_3 Wet Deposition			
2004	11	8	11
2003	23	20	23
2002	9	7	9
2001	26	20	26
Average:	17	15	16
NO_3 Dry Deposition	17	15	16
PO_4 Wet Deposition			
2004	0.7	0.5	0.7
2003	1.4	1.2	1.4
2002	0.6	0.4	0.6
2001	1.6	1.2	1.6
Average:	1.0	0.9	0.9
PO_4 Dry Deposition	1.0	0.9	0.9

Atmospheric Deposition Carpiteria Valley –

from Timothy Robinson PhD Dissertation: Catchment and Subcatchment Scale Linkages Between Land Use and Nutrient Concentrations and Fluxes In Coast California Streams. (University of California, Santa Barbara)

Additional sources for atmospheric deposition data:

S:\TMDLs & Watershed Assessme

S:\TMDLs & Watershed Assessme

S:\TMDLs & Watershed Assessme

Also, data is available from the National Atmospheric Deposition Program:

http://nadp.sws.uiuc.edu/

6.12 Loading Analysis

The following constitute a compilation of data sources that are available should any type of empirical loading analysis be deemed necessary in TMDL development.

6.12.1 Flow Data

Flow data is necessary for any type of loading analysis. Flow data was developed for the Lower Salinas Fecal Coliform TMDL and is available network directory:

S:\TMDLs & Watershed Assessment\TMDL and Related Projects- Region 3\Salinas River\Fecal coliform\3 Data Collection

6.12.2 Nutrient Export Coefficients

The Export Coefficient Model (ECM) (Reckhow et al., 1980) is a scoping model regularly used to compute lumped annual basin nitrogen or phosphorous loads based on summing nonpoint and point source estimated loads. The ECM requires the use of nutrient export coefficients. Nutrient export coefficients are the amounts of nitrogen or phosphorus exported from an area over a specific time period and are generally applied to a specific land use. They are typically expressed as kilograms of phosphorus per hectare per year, or pounds of nitrogen per acre per year, or some other mass-area-time unit.

The general form of the ECM is:

$$L_N = \sum_{i=1}^{n} [Ei * Ai] + S + W + P$$

Where:

L_N is the catchment nutrient load (kg/year);
E_i is the export coefficient (kg/ha/yr) for a land class i;
A_i is the area of the catchment occupied by land class i;
W is the waste water load from point sources (kg/yr);
S is the septic load (kg/yr);
P is the precipitation/atmospheric load (kg/yr)

In the absence of significant loads from point sources or septic, the nonpoint source land use load is the watershed summation of the *Ei* and *Ai* product alone, plus the atmospheric load.

Pollutant loads from various land uses can be calculated by applying appropriate export coefficients from published literature to the corresponding land use areas. Unfortunately, peer-reviewed nutrient export coefficients have not been reported for the Project Area or in Monterey County. However, numerous studies have derived land use based export coefficients characteristic of various watershed conditions for estimating nonpoint source pollutant yields (Boynton et al. 1993).

Despite the existence of scientifically peer-reviewed literature values, it is important to recognize that selection of nutrient export coefficients remains, to a degree, an unavoidably subjective task. Nutrient loading to streams is dependent on climate, catchment geology, vegetation, soil type, human activities and land use practices (Sharpley et al., 1994; Mulholland and Hill, 1997; Coulter et al., 2004). As a result, there is a wide range of reported nutrient export coefficients for various land uses. Therefore, it is important to apply best professional judgment and knowledge of local watershed conditions in choosing appropriate export coefficients.

Some researchers (Shaver et al., 2007; Joubert et al, 2003) indicated that the export coefficient model can be improved by establishing a range of areal loading rates (in contrast to a single export coefficient per land use category) from published literature sources to account for uncertainty or error. It is important to note that although there are a substantial amount of studies on the linkage between land use and nutrient export coefficients, comparable studies conducted in Mediterranean-like climates are rare. Mediterranean-like climates are characterized by high variability in precipitation and extended dry periods for which few nutrient export studies have been conducted. Consequently, staff identified a range of reasonable land use export coefficients from regions that have similar watershed characteristics to the Project Area of northern Monterey County; or alternatively by identifying "averaged" median national export coefficient values.

Accordingly, staff used a hierarchical approach to obtain a reasonable range of values for nutrient export coefficients by taking the following steps:

i. First, coefficients from a variety of studies and publications were obtained.
ii. From these literature-reported values, nutrient export coefficients from Level III Nutrient Ecoregion, Zone 6 (i.e., Southern and Central California Chaparral and Oak Woodlands ecogregion) were selected. Note that nutrient ecoregions are USEPA designations for subregions of the United States that denote areas with ecosystems that are generally similar (e.g., physiography, climate, geology, soils, land use, hydrology).
iii. Next, export coefficients from other nutrient ecoregions located in the State of California were selected.
iv. In the absence of Level III Zone 6 ecoregion data, or California-specific export coefficients, median national values, or regional values applicable to the western United States were selected.
v. Finally, local watershed conditions were considered in screening and culling the literature export coefficients. For example, reported national median export coefficient values for agricultural land uses that are not representative of the Project Area (e.g., corn, soybean, cotton) were not

selected for consideration. Where possible, export coefficients were selected that could reasonably be associated with Project Area-specific land uses.

Figure 6-29 illustrates the nutrient ecoregions of California and the locations of nutrient export coefficients used in this report.

Figure 6-28. Map of Nutrient Ecoregions of California and Locations of Literature Nutrient Coefficients Selected for Use in the TMDL Project.

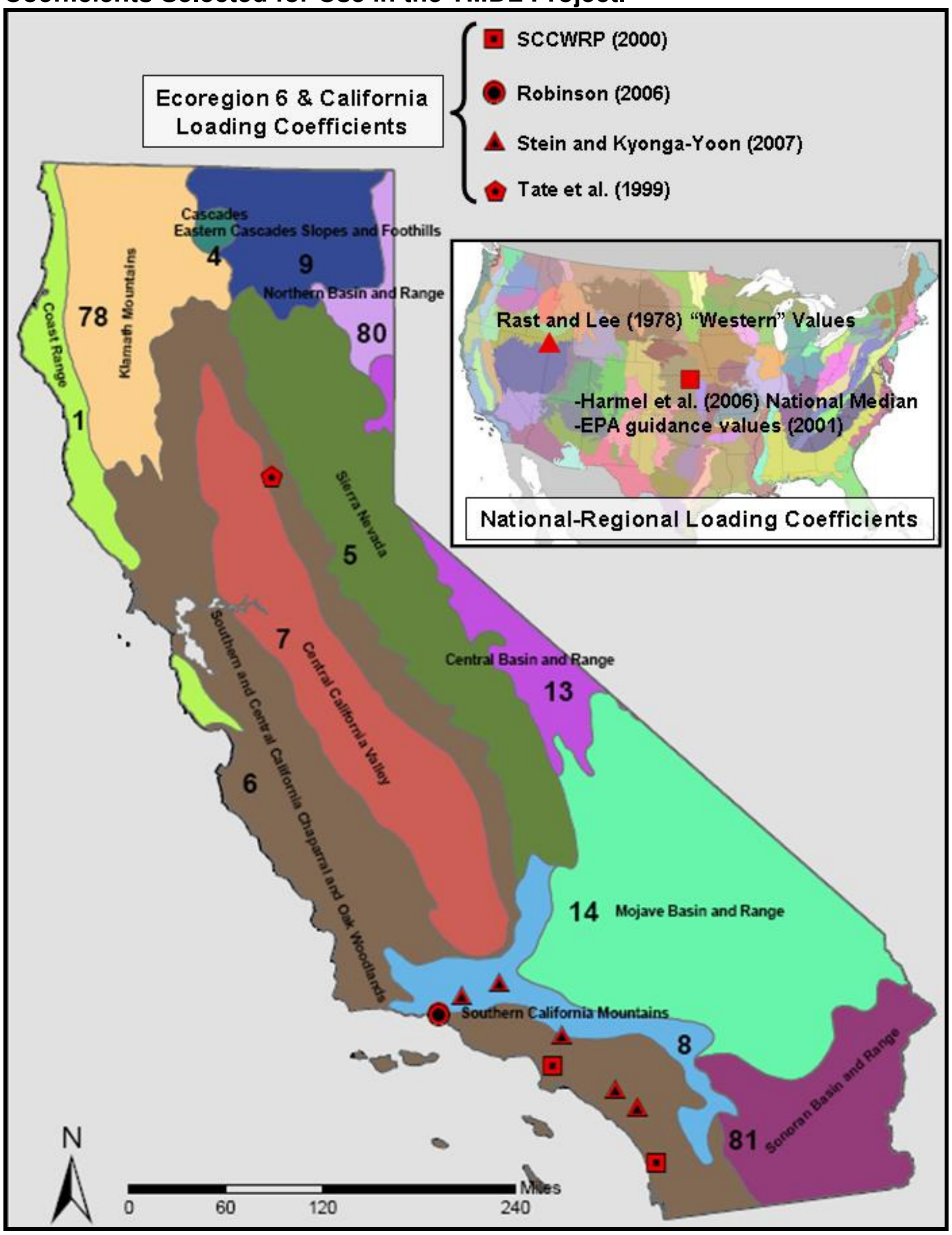


Table 6-6 compiles the values and ranges of nitrogen export coefficients used in this report.

Table 6-6. Selected Literature Nitrogen Export Coefficients (Units = kg/ha/year).

		Literature Source / Study Area							
Land Use	***Land Treatment or Subcategory***	**Rast and Lee (1983)**	**SCCWRP et al. (2000)**	**Harmel et al. (2006)**	**Robinson (2006)**	**USDA MANAGE Database**	**Stein and Kyonga-Yoon (2007)**	**Tate et al. (1999)**	**USEPA Nutrient TMDL Guidance (from Table 5-3, 2001)**
		"Western" Regional U.S. value	Coastal Southern California	Median National Values	Santa Barbara County Calif. (mean of dry and wet years)	Median National Values	Coastal Southern Calif. (Median Value for Four Watersheds)	Yuba County, Calif.- mean Value	Median Values
Agriculture-Cropland	Various Rotations	2.0 for all "ag"	4.4 for all "ag"	3.68	-	-	-	-	-
	Fallow Cultivated			3.0	-				
	Oats-wheat			6.61	-				
	Avocado			-	5.18				
Urban	Commercial-High Density	2.5 for all "urban"	4.7	-	12.93	-	-	-	5.8
	Residential		3.1		3.19	-			4
Pasture	Dryland alfalfa, barley, oats, etc.; No grazing to rotational grazing	-	-	0.97	-	0.8		-	4.2
	Pasture (grazed)					2.4			
Range/ Grassland	Native grass; No grazing to light grazing to moderate grazing	-	-	0.97	-	1.3	-	1.6	4.2
Forest/ Shrubland	Forest, Undeveloped Shrub Land	1	-	-	0.68		2.3	-	2
	"Open", undeveloped		0.9						
Wetland[A]		0	-	-	-	-	-	-	-

[A] Wetlands or marshes can act as sinks or sources of nutrients, depending upon the specific season of the year. It has been found, however, that the quantities of phosphorus that enter and leave wetlands over an annual cycle are essentially equal (as reported in Rast and Lee, 1983). On this basis, the net contribution of nutrients from wetlands is zero over the annual cycle

6.12.2.1 The MANAGE Method of Estimating Export Coefficients

Modifying Export Coefficients to Account for Variations in Runoff Potential: The MANAGE Method of Estimate Export Coefficients

In its traditional form the ECM assumes that export coefficient values are uniform for each land cover type or nutrient source within a catchment, regardless of proximity to water or hydrologic pathways. It is important to recognize that over large watershed areas, nutrient export may not be proportional to watershed area and some attenuation of nutrients occur due to variations in runoff rates, plant cover and retention, and travel distance to streams (Heathwaite and Burt, 1991; Minnesota Pollution Control Agency, 2003; Endreny and Wood, 2003; Theodore Endreny, personal communication, Nov. 2009). While the ECM is capable of generating reasonable estimates of nutrient loads simply from a watershed land cover data and associated homogeneous export coefficient values, research findings and professional literature suggest that <u>the export coefficients approach can be slightly modified</u> to account for field characteristics such as soil drainage, attenuation along hill slope runoff flow paths, and distance to streams from the contributing source area (Johnes and Heathwaite, 1997; McMahon and Roessler. 2002; Endreny and Wood, 2003; Mitsova-Boneva and Wang, 2008). Consequently, staff evaluated whether uniform land use export coefficients were appropriate, or whether modified export coefficients – taking into account watershed physical/spatial field characteristics – should be developed, as outlined below.

The Project Area is over 1,009 square kilometers, and has substantial variation in land cover, soils, and elevation. In addition, it is important to consider a watershed's drainage density, and how it qualitatively relates to the probability of material (e.g., nutrients) entering along a stream reach. Drainage density is simply a measure of how well or poorly a watershed is drained by stream channels, as is mathematically expressed as:

$$\text{Drainage Density} = \text{Stream Length} / \text{Basin Area}$$

Drainage density is dependent on climate, topography, vegetative cover, geology, and other conditions. The measurement of drainage density can provide a useful measure of runoff potential. On a highly permeable landscape, with low potential for runoff discharging directly to streams, drainage densities are sometimes less than 1 kilometer per square kilometer. Highly dissected watershed surface drainage densities can be tens or even hundreds of kilometers per square kilometer.

Staff calculated a drainage density of 1.01 kilometers per square kilometer for the Project Area, using a digital clipped river reach file, and a digital Project Area polygon.

Cumulative Stream Reach Length in Project Area	Project Area Size	**Drainage Density** (stream length / basin area)
1023 kilometers	**1010 km^2**	**1.01**

This drainage density qualitatively suggests that the Project Area, broadly speaking, has a relatively low potential for runoff discharging directly to a stream, compared to basins that are highly dissected by streams and have higher drainage densities. It is important to recognize however, that digital river reach files may not include field scale ditches, canals, and other unmapped water conveyance structures in the Project Area. Therefore the Project Area drainage density could be higher than the one calculated by Staff.

Based on the aforementioned information, Staff did not choose to apply uniform nutrient export coefficients for each land classification throughout the Project Area, as is often the case with the traditional Export Coefficient Model. Staff took into consideration in ruling out the use of uniform land use export coefficients:

- the large geographic scale of the project area;
- the heterogeneity of land cover and soils; and
- the relatively low drainage density of the project area.

Instead, Staff may employ recognized-approaches that allow for modification of the Export Coefficient Model, accounting for field characteristics such as soil drainage, and distance-decay factors related to the physical proximity (distance) of source areas to surface waterbodies.

One such method for employing a GIS-based pollution risk assessment to derive modified export coefficients is the "Method for Assessment, Nutrient-loading, And Geographic Evaluation of Nonpoint Pollution" (MANAGE). In the MANAGE method a mass balance approach is used to estimate nutrient (nitrogen and phosphorus) loading to surface water (Adamus and Bergman, 1993). Upper and lower limits are assigned for nitrogen and phosphorus delivery to surface water from each land use category in lb/acre/yr or kg/ha/yr. Then the hydrologic soil group (HSG) is used to determine a "most likely" nitrogen or phosphorus export coefficient for a particular land use is calculated for each SOIL / LAND USE combination as:

$$PC = LPC + (HPC - LPC) \times X$$
$$NC = LNC + (HNC - LNC) \times X$$

where
PC or NC = Most likely export coefficient for phosphorus (P) or nitrogen (N)
LPC or LNC = Lower limit export coefficient for P or N
HPC or HNC = Upper limit export coefficient for P or N
X = Value associated with each HSG (see Table 6-7)

Table 6-7. Weighting Factors (X) Used for Different Hydrologic Soil Groups in Equation X.

Hydrologic Soil Group (HSG)	Value of X
A	0

Hydrologic Soil Group (HSG)	Value of X
B	1/3 (0.33)
C	2/3 (0.67)
D	1

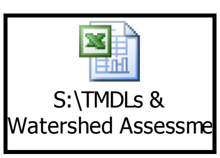
Essentially this formula divides the range of export coefficients evenly into quarters, with the high end assigned to hydrologic soil group A (high infiltration/low runoff rate) and the low end assigned to hydrologic soil group D (very slow infiltration/high runoff rate). The MANAGE model indicates that this based on the approach developed by Adamus and Bergman (1993).

Using the range of literature nitrogen export coefficients from Table 6-6, and the MANAGE Model equation, Table 6-8 shows the calculated most likely nitrogen export coefficients for each Land Use/Soil combination.

Table 6-8. Total Nitrogen Export Coefficients (kg/ha/year) for Each Soil/Land Use Combination in Project Area.

Land Use Category	Export Coefficient Reference Values		Calculated Most Likely Export Coefficient Based on Hydrologic Soil Group			
	LNC	HNC	A	B	C	D
Agriculture/Cropland	2	6.61	2	3.52	5.09	6.61
Urban Commercial	2.5	12.93	2.5	5.94	9.49	12.93
Urban Residential	2.5	4	2.5	3.0	3.5	4
Pasture	0.8	4.2	0.8	1.92	3.08	4.2
Range/Grazing Land	0.97	4.2	0.97	2.04	3.13	4.2
Forest	0.68	2.3	0.68	1.21	1.77	2.3
Wetland	0	0	0	0	0	0

A compilation of literature-reported nutrient export coefficients is available in the embedded spreadsheet.



Phosphorus loading coefficients have not been developed for this Phase 3 data analysis report, but may be developed in substantially the same way that the nitrogen loading coefficients were developed as above.

6.12.2.2 Distance Attenuation of Export Coefficients

Modifying Export Coefficients to Account for Distance Attenuation of Export Coefficients:

As noted earlier, in addition to using soil data to account for spatial variations in runoff potential (as in the MANAGE method above), researchers have also identified that there is some attenuation of nutrients occur due to travel distance to streams. Clearly, pollutants generated at a certain location are subject to degradation and transformation processes. One such process is the travel distance or travel time to the nearest stream discharge point.

Over large watershed areas, some researchers have noted that nutrient export is not proportional to watershed area and some attenuation of nutrients occurs, especially in natural vegetation that have low runoff rates. Recently, researchers who have examined the nutrient export issue on landscape level scales (large watersheds and higher order streams) have raised concerns over the applicability of uniform export coefficients across large watershed areas (Birr and Mulla, 2001; Cammermeyer, et al, 1999; Johnson and gage, 1997; Jones, et al, 2001; Mattson and Isaac, 1999; McFarland and Hauck, 1998; Richards, et al, 2001;Sharpley, et al, 1993; Soranno, et al, 1996; Worrall and Burt, 1999). The underlying issue related to this concern is that not all areas in a large watershed contribute nutrients equally. In its traditional form the ECM assumes that nutrient export coefficients are homogeneous within each land cover type, yet basic nutrient runoff and hydrological theory suggests that runoff rates have spatial patterns controlled by filtering and attenuation along the flow paths from the upslope contributing area to the downslope stream discharge point (Endreny and Woods, 2003).

Johnes and Heathwaite (1997) suggested that greater rates of nutrient export occur for sources located within the riparian zones than for those at distance from the stream. Accordingly, Johnes and Heathwaite (1997) used a distance decay function to model the impact of land use change on nitrogen and phosphorus concentrations in streams. They argued that nutrient-contributing areas greater than 50 meters from the drainage network were less important than near-stream zones due to attenuation and uptake of nutrients during downslope transit and that export coeffcients for each land use can be adjusted for each field in a catchment with respect to their proximity to surface waterbodies. In other words, areas within the 50 m wide riparian zone, were defined as high risk areas, with a higher index of nutrient export than similar land use types outside this zone. Jones and Heathwaite concluded that nutrient contributing areas outside the 50 meter riparian zone is subject to at least a 50% attenuation rate.

Based on the aforementioned research, distance-decay weighting of export coefficients has been utilized in nutrient TMDL development. For example, in the USEPA-approved State of New Mexico Rio Hondo TMDL (2005), the Export Coefficient Model (Reckhow, et al., 1980) was modified by weighting the nitrogen export based on distance from the stream with 50 meter, 500 meter, and 5000 meter buffer zones. The largest unit load was assigned to the 50 meter zone and the smallest unit-area load was assigned to the 5000 meter zone. In other words, the approach assumed that the export coefficient values undergo a step-wise decay when originating beyond the 50 meter distance cutoff and that nutrient loading is buffered beyond this distance.

Table 6-9 tabulates the distance decay attenuation coefficients derived from the aforementioned research and TMDL studies, and presents provisional distance decay attenuation coefficients for use in the Lower Salinas River watershed nutrient TMDL. As shown in the table, export coefficients associated with a particular land use category are attenuated by 50 % outside the 50 meter riparian buffer, and by 90% outside a 500 meter buffer. It is important to note that for the lower Salinas River nutrient project it may be prudent to use a 60 meter riparian buffer, rather than a 50 meter buffer. This is due to the fact that land use raster grid data available for use in GIS have a grid increment of 30 m. A 60 meter spatial buffer would be an increment of measurement exactly 2 times the raster grid sampling density.

Table 6-9. Weighting Coefficients for Modified Nutrient Export Coefficients based on Distance Attenuation.

	Relative Nutrient Loading Risk		
	Higher	***Moderate***	***Lower***
Source/Study	**50 m Buffer**	**> 50 m to < 500 m Buffer**	**> 500 m Buffer**
Johnes and Heathwaite (1997)	1.0	0.5	N.A.
New Mexico Rio Hondo Nutrient TMDL	1.0	0.5	0.1
Lower Salinas Nutrient TMDL (provisional)	1.0	0.5	0.1

Conceptually, the modification of land use-based export coefficients using the MANAGE method and distance-to-stream attenuation as detailed above, can be illustrated as shown in Figure 6-30:

Figure 6-29. Modifying Export Coefficients.

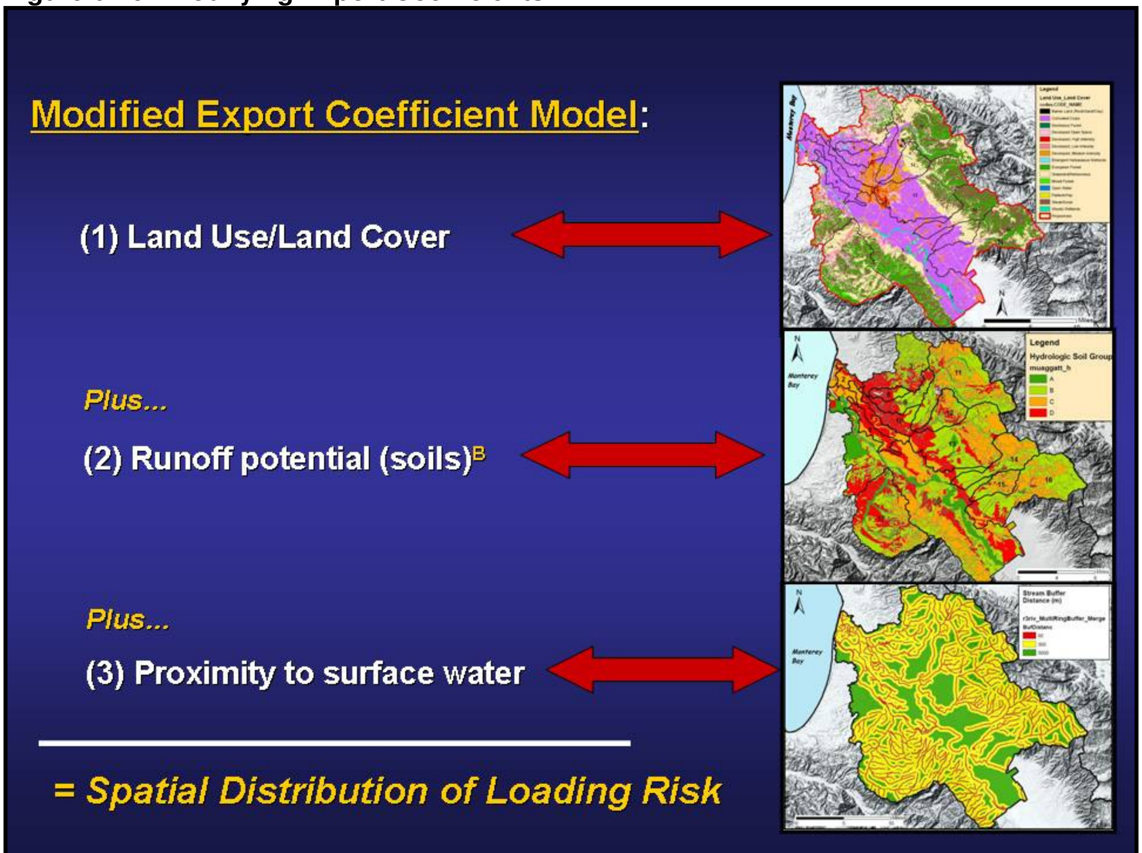
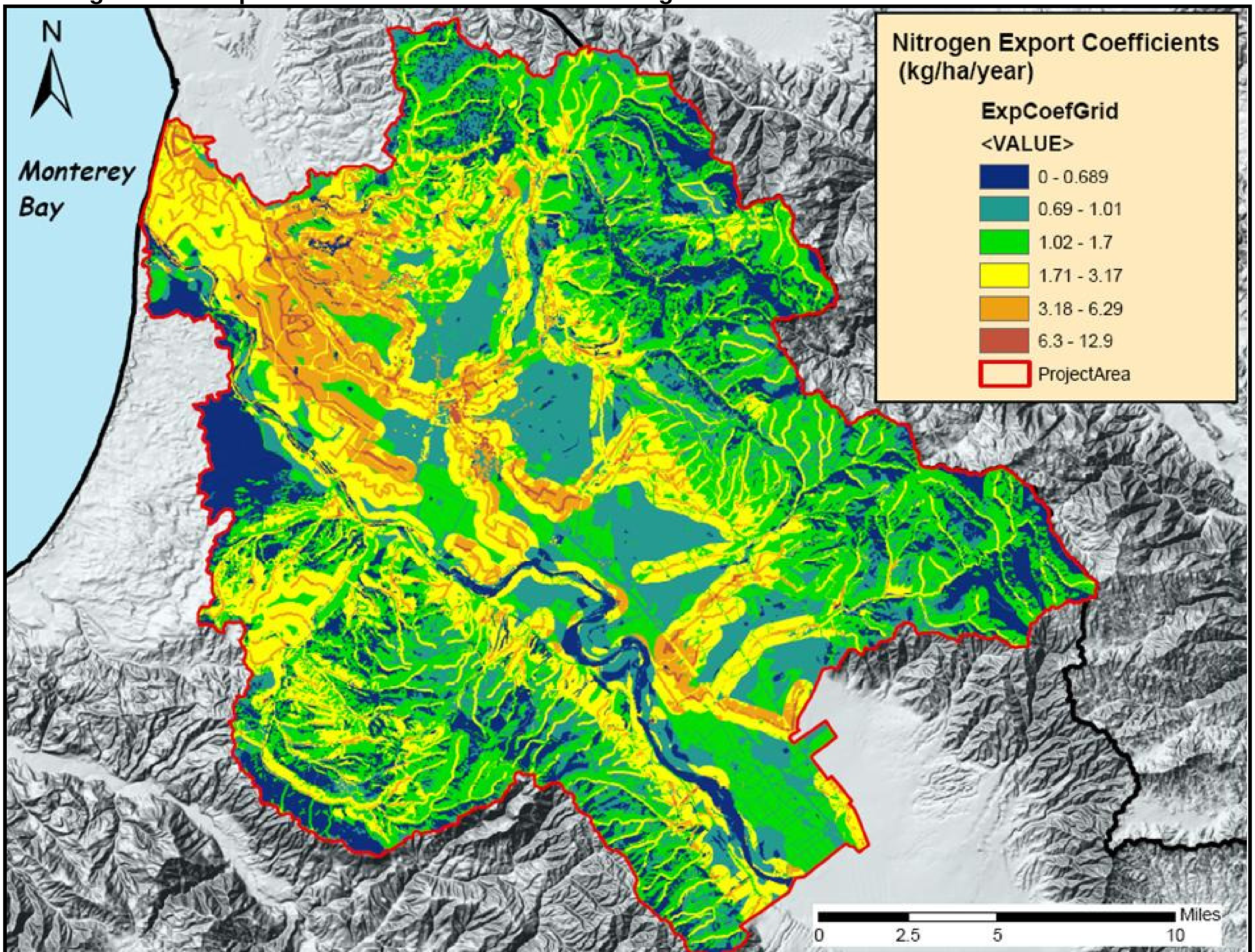


Figure 6-31 illustrates a preliminary and provisional export coefficient model for total nitrogen which incorporates weighting factors to standard export coefficients based on the land use / hydrologic soil group/ and distance to stream combinations, as outlined above.

Figure 6-30. Export Coefficient Model for Total Nitrogen in Lower Salinas River Watershed.



6.12.3 Flow Travel Times (Attenuation due to in-stream nitrogen loss)

It may be important to consider the potential for instream attenuation of nutrients in terms of doing loading analysis. Valigura et al. (2001) reported total nitrogen in-stream loss rates for drainages of major estuaries of the conterminous United States. The data Valigura et al. provided indicates that all stream flow travel times of $\leq$ one day result a range of nominal (less than 8%) to negligible (near zero) in-stream total nitrogen loss. 0.6 days result in negligible in-stream total nitrogen losses; and that all travel time less than one day result in nominal (less than 10%) to negligible (near zero) total nitrogen in-stream losses (see Figure 6-32).

Figures 6-33 through 6-34 illustrate subwatershed mean stream travel times in the project area based on NHDplus flow attributes.

Figure 6-31. Total Nitrogen Loss Rates Based on Stream Flow Travel Time (data from Table 7 in Valigura et al., 2001)

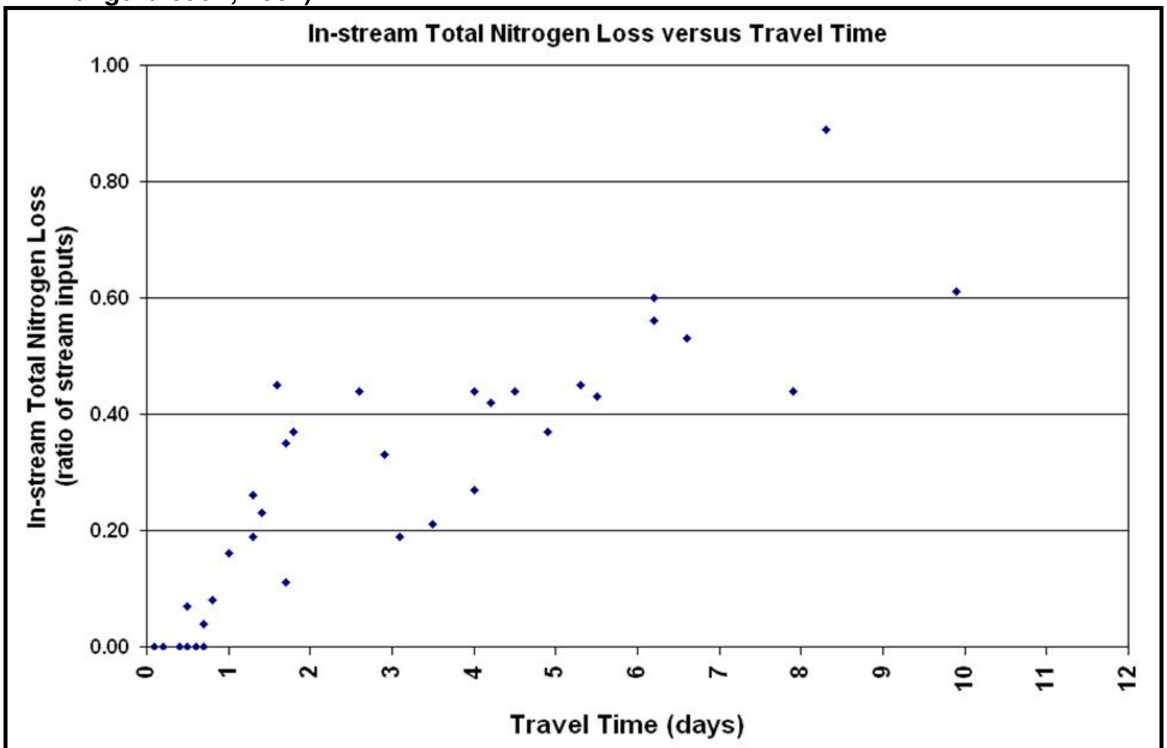
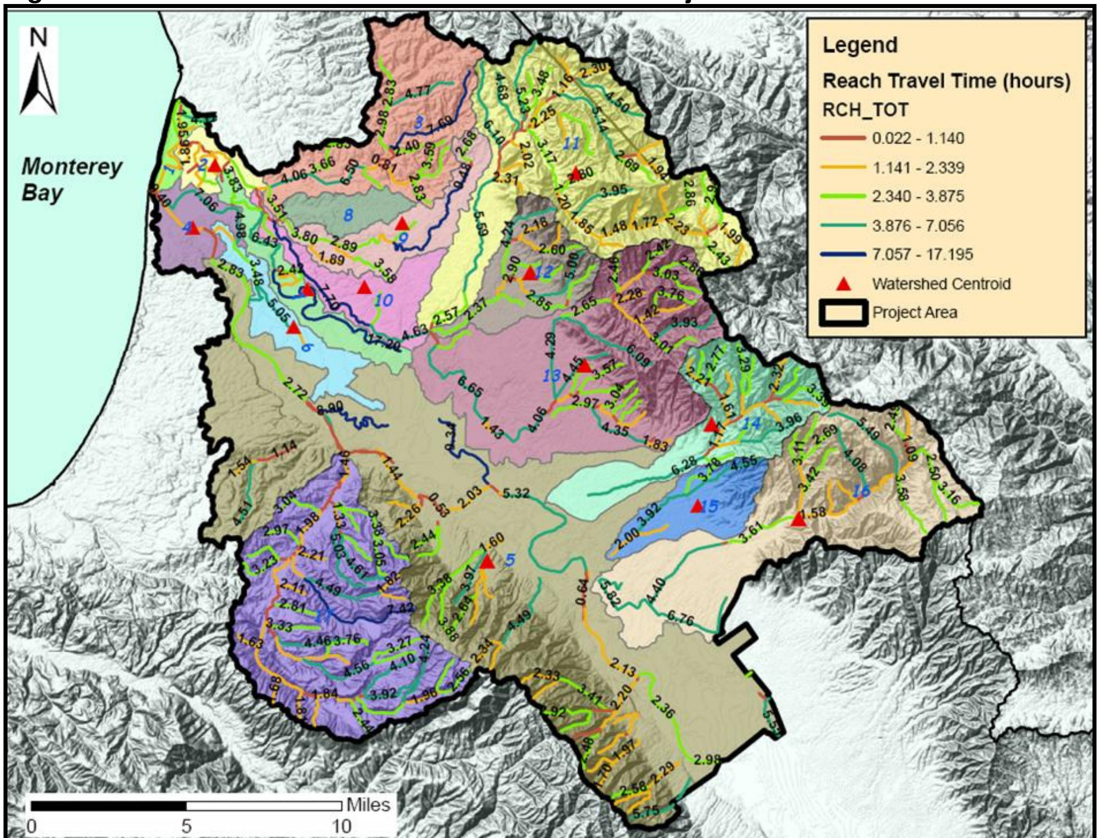


Figure 6-32. Estimated Mean Flow Travel Times in Project Area Stream Reaches.



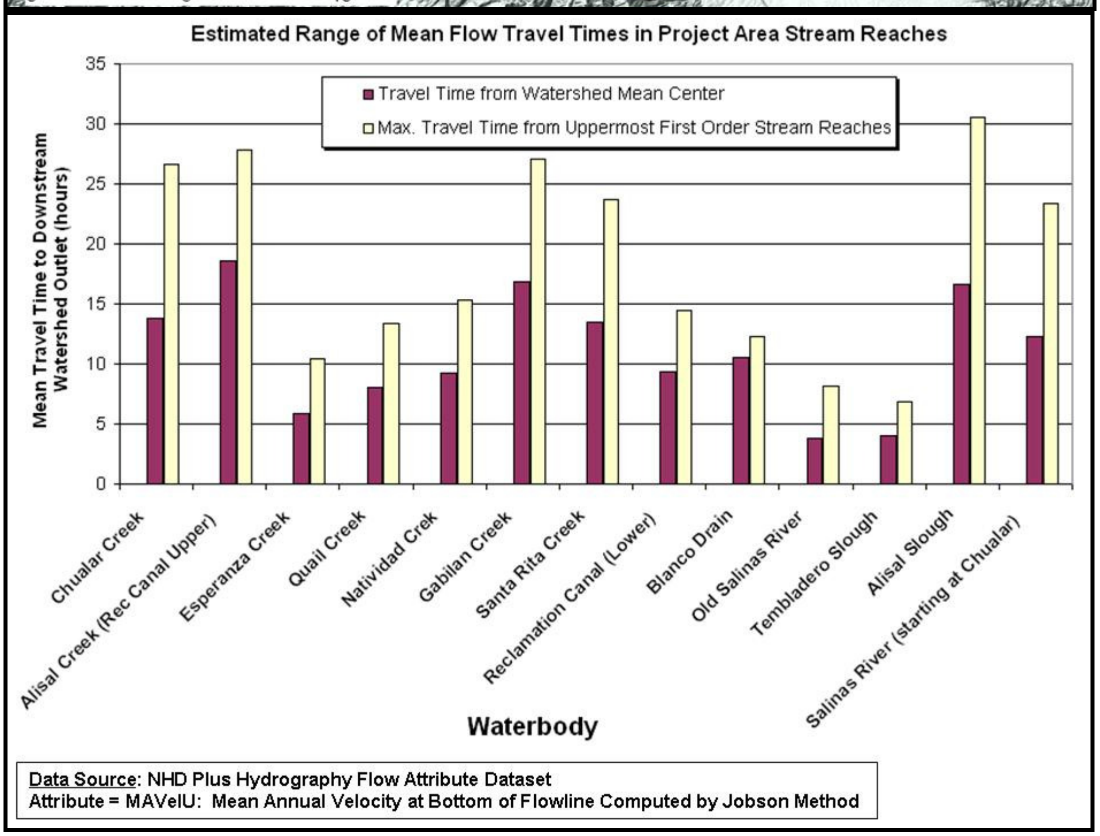


Figure 6-33. Range of Estimated Mean Flow Travel Times in Project Area Watersheds.

7 NUTRIENT CRITERIA DEVELOPMENT

7.1 Background

It is important to note that documenting high total nitrogen and total phosphorus concentrations is not sufficient in/of itself to demonstrate a risk of eutrophication. Research has demonstrated the shortcomings of using ambient nutrient concentrations within a waterbody alone to predict eutrophication, particularly in streams (TetraTech, 2006). TetraTech (2006) goes on to note that except in extreme cases, nutrients alone do not impair beneficial uses. Rather, they cause indirect impacts through algal growth, low dissolved oxygen, and so on, that impair uses. These impacts are associated with nutrients, but result from a combination of nutrients interacting with other factors.

Accordingly, it is typically necessary and appropriate to document that aquatic habitat is impaired due to excessive nutrients by evaluating secondary indicators:

- Nuisance algal blooms (excess periphyton growth)
- Dissolved oxygen violations
- Huge daily swings in dissolved oxygen
- Undesirable shifts in the native species of plants and animals
- Loss of habitat
- Excess nutrient loads result in (a) excess planktonic biomass (larger, slow moving rivers) and/or (b) excess periphyton or macrophyte biomass (smaller, higher gradient systems) that may alter the food chain and benthic habitat, cause unaesthetic conditions, and alter DO balance, leading to impairment of uses. (from State Board NNE presentation, Dallas, TX, 2006)

It is also important to assess temporal trends and spatial trends that pertain to the risk of eutrophication. For example:

Nutrient Impacts – When/Where do These Impacts Occur?

- Downstream of “food” sources (WWTP, Urban runoff, etc)
- During periods of low flow, low velocity, and high temperature.
- Areas where the river is wide, water is shallow, tree canopy is open and light is readily available.

Limitations on using nutrient concentrations as a predictor of eutrophication are noted in the Tetratech Final California NNE Report (TetraTech, 2006) – (emphasis added):

> Several researchers have demonstrated the **shortcomings of using ambient nutrient concentrations within a waterbody alone to predict eutrophication, particularly in streams** (Heiskary and Markus, 2001; Prairie et al., 1989; Welch et al., 1989; Chételat, et al., 1999; Dodds et al.,

2002; Fevold, 1998; Van Nieuwenhuyse and Jones, 1996). Ambient concentration data may not be effective in assessing eutrophication and the subsequent impact on water use because algal productivity depends on several additional factors such as morphology, light availability, flooding frequency, biological community structure, etc.

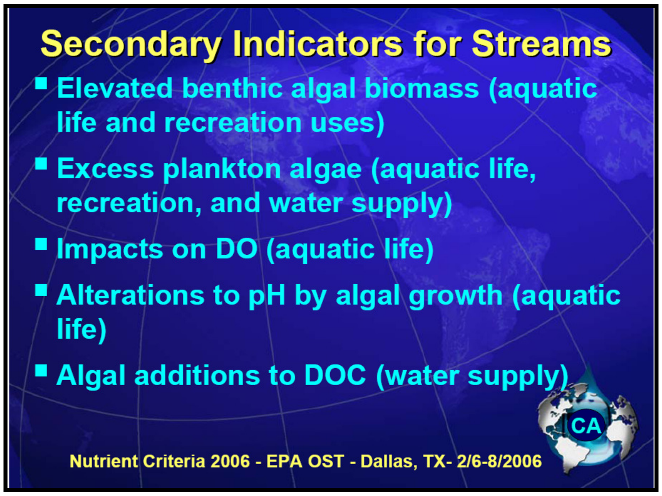
The problems associated with using nutrient concentrations alone to predict use-support status are demonstrated by a California pilot study conducted in Ecoregion 6 (Tetra Tech, 2003)

Welch et al. (1989) suggest that a dynamic modeling approach is necessary to quantitatively evaluate nutrient-biomass relationships for a particular system. It is not feasible to set up such models for each water body in California to determine use status. It is against this background that the California approach described in this report suggests **secondary response indicators in place of complex models or simplistic nutrient concentration limitations to assess use support status.** Also, from TetraTech, 2004: Both chemical concentrations as well as biological responses should be part of the criteria. Figure 1 illustrates in a simplified form the relationship between the loads and beneficial uses, and identifies the interactions that are the typical focus of TMDL analyses and the subset of interactions that will be studied in the nutrient criteria development process. The role of exogenous factors such as flow, sediment load, habitat quality, temperature, and shade, on biological responses is also shown. Because TMDL analyses are focused on an individual water body, as opposed to groups of water bodies in the criteria development process, it is possible to do a much more detailed analysis of the connections between initial biological responses and beneficial uses in that water body."

7.2 Secondary Indicators for Stream

This section compiles information on secondary indicators for streams, as documented in available published reports. Secondary indicators are defined in the narrative and figure from the Stateboard NNE Presentation (Nutrient Criteria, EPA OST, Dallas, TX 2006) as shown below:

*"**Secondary indicators provide more direct linkage** to beneficial uses than nutrient concentrations alone" (State Board, 2006)*



”

From the Region 2 Approach for Developing Nutrient TMDLs (2003), information on algal growth, oxygen depletion, and nutrient limiting ratios are shown below (emphasis added):

> Preliminary data indicate that periphyton growth in freshwater streams is the most prevalent type of eutrophication problem in Bay Area waterbodies. For this reason, this report focuses mainly on periphyton. However, many of the principles discussed apply to other types of nuisance growth.
>
> Many interacting factors determine periphyton growth rates. Some of the most important factors (illustrated in Figure 4) are:
> External nutrient loading—nutrients entering the stream via surface runoff, groundwater seepage, or precipitation—is the primary source of nutrients for algal growth. The form of nutrients entering the water also affects algal growth rates. Dissolved inorganic nutrients are generally more available to algae, and tend to have a greater stimulatory effect on algal growth than organic and particulate forms of nutrients.
> • Internal loading can also be a significant nutrient source. Internal loading is the release of nutrients stored in the sediment or in decaying biomass back into the water column, where it is again available for algal uptake.
> • Light is essential for photosynthesis, and therefore the shade provided by riparian vegetation can be a major limiting factor on algae growth in streams.
> • Streamflow can influence algal growth in two ways. Very low flows have been shown to inhibit algal growth by limiting nutrient transport to and into growing algal masses (Stevenson, 1997). Extremely high flows inhibit biomass accumulation by detaching algae and transporting it downstream.
> • Grazing of algae by benthic macroinvertebrates is important in controlling the accumulation of algal biomass, and under some circumstances can prevent excessive algal growth even when nutrient and light conditions are optimal for growth (Biggs, 2000).

Periphyton growth in Bay Area streams occurs primarily from **late spring though early autumn**. This is the period when **temperatures and light levels are optimal** for algal growth, and **when scouring high flow conditions are absent**. However, it is also the period when external nutrient loads are lowest. Loading through surface runoff is low or completely absent in the summer months, so external loading occurs almost exclusively through groundwater seepage. Limited loading combined with rapid uptake by the growing mass of algae tends to result in declining nutrient concentrations throughout the summer months. Eventually nutrient concentrations may become so low that they limit further algal growth. The exact nutrient levels at which algal growth limitation begins to occur vary, but are generally less than 0.5 mg/L for total nitrogen and 0.1 mg/L for total phosphorus (Bowie et al., 1985). If nutrient concentrations fall to limiting levels early in the season, only a modest standing crop of algae will be produced; if limiting concentrations do not occur until later, or if nutrient levels remain high all summer, large, problematic quantities of algal biomass may develop (Biggs, 2000; Dodds and Welch, 2000).

Whether nitrogen or phosphorus **limits algal growth** is a function of the ratio of these elements in the water. **Algae utilize nitrogen and phosphorus at a ratio of about 7:1 by mass**. A ratio of these elements significantly narrower than 7:1 means that there is a greater supply of phosphorus than nitrogen, relative to algal needs, and nitrogen is limiting growth. A wider ratio than 7:1 implies the opposite: phosphorus limits growth. A ratio close to 7:1 suggests that either or both elements may be limiting. Nitrogen appears to be the limiting nutrient in most Bay Area freshwater systems. This issue can have major implications for load reduction strategies, since different nutrient sources can be relatively higher in one of these elements than the other.

Oxygen depletion is an important effect of excessive algal growth due to its direct negative impact on aquatic life. Most native aquatic organisms found in streams are adapted to high levels of dissolved oxygen, and when oxygen levels fall, these organisms must either leave the system or die. Factors that consume oxygen in aquatic systems include decomposition, biological oxidation of ammonia to nitrate (nitrification), and respiration. In pristine streams these processes are fairly slow relative to reoxygenation from the atmosphere, and dissolved oxygen levels remain near equilibrium with the atmosphere, that is, near 100% saturation. Excessive nutrient loading can drastically accelerate algal-related oxygen-consuming processes—respiration by living algal cells, and decomposition of dead algal material—causing severe oxygen depletion.

> Dissolved oxygen monitoring efforts must account for the natural fluctuations that result from algal production of oxygen as a by-product of photosynthesis. Photosynthesis occurs only during daylight hours, while oxygen-consuming processes occur 24 hours a day. As a result, daytime oxygen levels are often high—sometimes supersaturated—in nutrient-impaired systems. Concentrations typically peak late in the afternoon when photosynthetic oxygen production dominates, and are lowest in the pre-dawn hours, when respiration and decomposition are dominant (Figure 5). In seriously impaired streams, oxygen levels can range from 0% to over 200% saturation over a 24-hour period. For this reason, daytime dissolved oxygen measurements are of limited value in assessing nutrient problems. Pre-dawn measurements are better, and continuous or semi-continuous monitoring is ideal. In some waterbodies, even continuous dissolved oxygen measurements may not be sufficient to evaluate impairment. In shallow, rapidly flowing streams, reaeration can be so rapid that dissolved oxygen in the water column remains high even when profuse periphyton growth smothers bottom habitat, impairing the important benthic component of the stream community. In these cases it may be possible to detect algal impairment of habitat through biological indicators, such as benthic macroinvertebrate community structure.

Above from: Region 2 "Conceptual Approach for Developing Nutrient TMDLs for San Francisco Bay Area Waterbodies, June 18, 2003.

From the State Board division of water quality staff report on nutrient screening tools for use in the clean water act section 303(d) listing process (2007):

> The tradition, in the study of streams and lakes, has been to use the measure of chlorophyll-*a* (Chl-*a)* as a surrogate measure of plant or algal biomass. Because it is relatively easy to measure, a response target defined as a concentration of Chl-*a* provides a natural basis for assessing (beneficial) use support status in response to nutrient enrichment. Chl-*a* is one of the items referred to as Secondary Indicator Response Variables (SIRV) in the California NNE. In lakes and lentic water bodies it is measured as benthic algal biomass (in µg/l), and for rivers and streams, periphytic algal biomass (measured as Chl-*a* per unit area) is used. The California NNE technical approach uses preliminary numeric targets called Beneficial Use Risk Categories (BURC boundaries) for the secondary indicator of Chl-*a* using literature sources and elicitation from the Regional Water Boards. These numeric targets are shown in Table 1 and were set at a conservative level to account for uncertainty and to be applicable throughout California.

TABLE 1

Nutrient Numeric Endpoints for Secondary Indicators - Proposed Risk Classification Category Boundaries: I & II and II & III

Beneficial Use Risk-Category I. Presumptive unimpaired (use is supported)
Beneficial Use Risk Category II. Potentially impaired (may require an impairment assessment)
Beneficial Use Risk Category III. Presumptive impaired (use is not supported or highly threatened)

RESPONSE VARIABLE	RISK – CATEGORY BOUNDARY	BENEFICIAL USE						
		COLD	WARM	REC-1	REC-2	MUN[1]	SPWN	MIGR
Benthic Algal Biomass in streams (mg chl-*a*/m^2) Maximum	I / II	100	150	C	C	100	100	**B**
	II / III	150	200	C	C	150	150	**B**
Planktonic Algal Biomass in Lakes and Reservoirs (as µg/L Chl-*a*)[2] – summer mean	I / II	5	10	10	10	5	**A**	**B**
	II / III	10	25	20	25	10	**A**	**B**

A = No direct linkage
B = More research needed to quantify linkage
C = Addressed by Aquatic Life Criteria
1. For application to zones within water bodies that include drinking water intakes.
2. Reservoirs may be composed of zones or sections that will be assessed as individual water bodies

7.3 EPA Nutrient Criteria

In 2000, the USEPA published ambient numeric criteria to support the development of State nutrient criteria in rivers and streams of Nutrient Ecoregion III (Xeric West). Narrative from the 2000 USEPA guidance is reproduced below (emphasis added):

(The 2000 report) presents EPA's nutrient criteria for **Rivers and Streams in Nutrient Ecoregion III.** These criteria provide EPA's recommendations to States and authorized Tribes for use in establishing their water quality standards consistent with section 303(c) of CWA. Under section 303(c) of the CWA, States and authorized Tribes have the primary responsibility for adopting water quality standards as State or Tribal law or regulation. The standards must contain scientifically defensible water quality criteria that are protective of designated uses. EPA's recommended section 304(a) criteria are not laws or regulations – they are guidance that States and Tribes may use as a starting point for the criteria for their water quality standards.

In developing these criteria recommendations, EPA followed a process which included, to the extent they were readily available, the following elements critical to criterion derivation:

Historical and recent nutrient data in Nutrient Ecoregion III. Data sets from Legacy STORET, NASQAN, NAWQA and EPA Region10 were used to assess nutrient conditions from 1990 to 1998.

Reference sites/reference conditions in Nutrient Ecoregion III. Reference conditions presented are based on 25th percentiles of all nutrient data including a comparison of reference condition for the aggregate ecoregion versus the subecoregions. States and Tribes are urged to determine their own reference sites for rivers and streams within the ecoregion at different geographic scales and to **compare** them to EPA's reference conditions.

The intent of developing ecoregional nutrient criteria is to represent conditions of surface waters that are minimally impacted by human activities and thus protect against the adverse effects of nutrient overenrichment from cultural eutrophication. EPA's recommended process for developing such criteria includes physical classification of waterbodies, determination of current reference conditions, evaluation of historical data and other information (such as published literature), use of models to simulate physical and ecological processes or determine empirical relationships among causal and response variables (if necessary), expert judgment, and evaluation of downstream effects. To the extent allowed by the information available, EPA has used elements of this process to produce the information contained in this document. The values for both causal (total nitrogen, total phosphorus) and biological and physical response (chlorophyll *a*, turbidity) variables **represent a set of starting points** for States and Tribes to use in establishing their own criteria in standards to protect uses.

The values presented in this document generally represent nutrient levels that protect against the adverse effects of nutrient overenrichment and are based on information available to the Agency at the time of this publication. However, States and Tribes should critically evaluate this information in light of the specific designated uses that need to be protected.

-from: Ambient Water Quality Criteria Recommendations – River and Streams in Nutrient Ecoregion III, USEPA December 2000.

EPA technical guidance recommended two approaches to setting nitrogen reference conditions. The preferred approach was to use the 75th percentile of data from a set of reference sites. The other approach was to use the 25th percentile of all data. Using the second approach, EPA derived a reference value of 0.38 mg/L total nitrogen (TN) for the xeric west (which includes the Central Coast Region), and also identified a subregional value of 0.52 mg/L TN for the Central and Southern California chaparral ecoregion (U.S. EPA, 2000).

With regard to selecting reference sites, USEPA guidance for selecting reference stream as shown below:

"A reference stream is a least impacted waterbody within an ecoregion that can be monitored to establish a baseline to which other waters can be compared. Reference streams are not necessarily pristine or undisturbed by humans."

-From: USEPA, 2000 accessed at

http://www.epa.gov/waterscience/criteria/nutrient/guidance/rivers/rivers-streams-full.pdf

EPA proposed that the 25th percentiles of all nutrient data could be assumed to represent unimpacted reference conditions for each aggregate ecoregion, and also provided a comparison of reference condition for the aggregate ecoregion versus the subecoregions. These 25th percentile values were characterized as criteria recommendations that could be used to protect waters against nutrient over-enrichment (USEPA, 2000). However, EPA also noted that States and Tribes may "need to identify with greater precision the nutrient levels that protect aquatic life and recreational uses.

The central coast region is in Aggregate Nutrient Ecoregion 3. There are twelve Level III ecoregions (subecoregions) within Aggregate Ecoregion 3. The central coast is included in Level III subecoregion 6 (see Figure 7-1):

6. Southern and Central California Chaparral and Oak Woodlands

The primary distinguishing characteristic of this ecoregion is its Mediterranean climate of hot dry summers and cool moist winters, and associated vegetative cover comprising mainly chaparral and oak woodlands; grasslands occur in some lower elevations and patches of pine are found at higher elevations. Most of the region consists of open low mountains or foothills, but there are areas of irregular plains in the south and near the border of the adjacent Central California Valley ecoregion. Much of this region is grazed by domestic livestock; very little land has been cultivated.

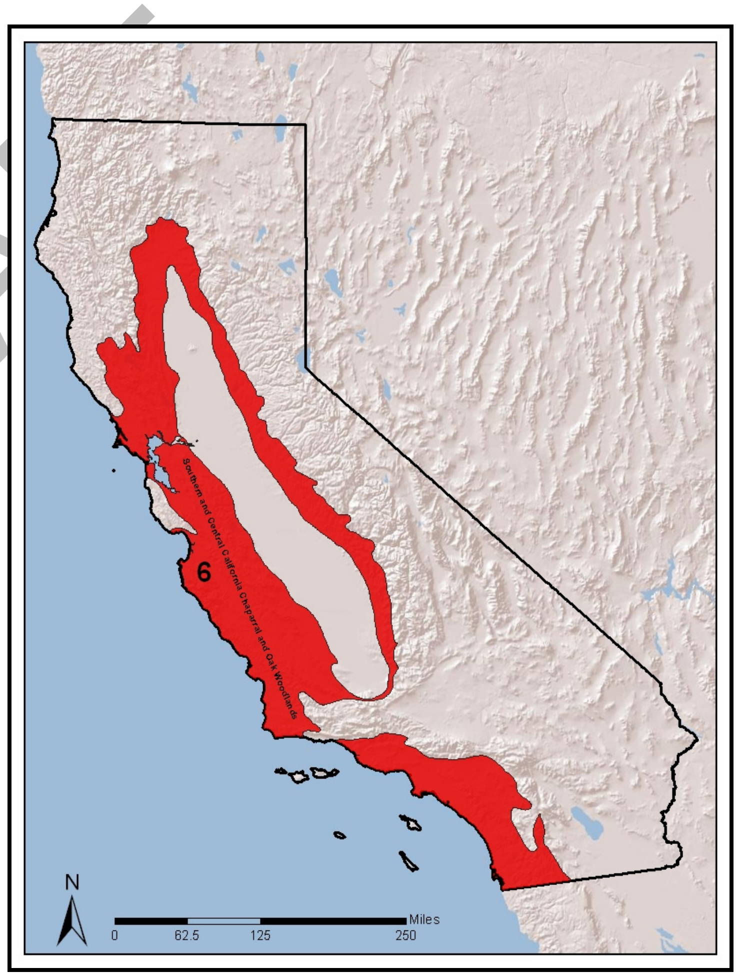


Figure 7-1. Southern and Central California Chaparral and Oak Woodlands Ecoregion.

7.3.1 Reference Conditions for Ecoregion III Streams

USEPA's 25th percentiles (representing unimpacted reference conditions) for aggregate Ecoregion III streams (Xeric West) are shown below:

Figure 7-2. USEPA Reference Conditions for Aggregate Ecoregion III Streams.

Parameter	No. of Streams N ++	Reported values		25th Percentiles based on all seasons data for the Decade	Reference Streams **
		Min	Max	P25-all seasons+	P75 - all seasons
TKN (mg/L)	733	0	13.05	**0.198**	
$NO_2 + NO_3$ (mg/L)	459	0	9.66	**0.025**	
TN (mg/L) - calculated	NA	0	22.71	**0.223**	
TN (mg/L) - reported	154	0.43	10.58	**0.377**	
TP (*ug*/L)	808	0	12,787.5	**21.88**	
Turbidity (NTU)	181	.288	157.8	**1.84**	
Turbidity (FTU)	407	0	160	**234**	
Turbidity (JCU)	1z	14.9	14.9	**14.9**	
Chlorophyll *a* (*ug*/L) -F	24	0.3	27	**1.78**	
Chlorophyll *a* (*ug*/L) -S	23	0.205	60.35	**1.43**	
Chlorophyll *a* (*ug*/L) -T	16	0.95	19.475	**5.625**	
Periphyton Chl *a* (mg/m^2)	3 z F	43.9	65	**43.9 zz**	

USEPA's 25th percentiles (representing unimpacted reference conditions) for Aggregate Ecoregion III, subecoregion 6 (Central and Southern Calif. Oak and Chaparral) streams are:

- **0.52 mg/L total nitrogen, and**
- **0.03 mg/L total phosphorus**
- **2.39 mg/L chlorophyll *a***
- **1.9 (NTU) turbidity**

as shown below (Figure 7-3):

Figure 7-3. USEPA Reference Conditions for Level III Ecoregion 6 Streams.

Parameter	No. of Streams N ++	Reported values		25th Percentiles based on all seasons data for the Decade	Reference Streams **
		Min	Max	P25-all seasons+	P75 - all seasons
TKN (mg/L)	40	0.05	4.25	0.363	
$NO_2 + NO_3$ (mg/L)	17	0.025	8.275	0.155	
TN (mg/L) - calculated	NA	0.075	12.525	0.518	
TN (mg/L) - reported	10	0.223	9.95	0.5	
TP (ug/L)	23	2.5	3212.5	30	
Turbidity (NTU)	13w	1	35.875	1.9	
Turbidity (FTU)	21	0.775	47.25	2.65	
Turbidity (JCU)	-	-	-	-	
Chlorophyll *a* (ug/L) -F	0z	-	-	-	
Chlorophyll *a* (ug/L) -S	2z,w	2.3915	2.3915	2.3915	
Chlorophyll *a* (ug/L) -T	0z	-	-	-	
Periphyton Chl *a* (mg/m^2)	-	-	-	-	

P25: 25th percentile of all data
P75: 75th percentile of all data
** as determined by the Regional Technical Assistance Groups (RTAGs)
\+ Median for all seasons' 25th percentiles. E.g. this value was calculated from four seasons' 25th percentiles. If the seasonal 25th percentile (P25) TP values are - spring 10ug/L, summer 15ug/L, fall 12ug/L, and winter 5ug/L, the median value of all seasons P25 will be 11ug/L.
++ N = largest value reported for a decade / Season.
TN calculated is based on the sum of TKN + NO_2+NO_3.
TN reported is actual TN value reported in the database for one sample.
F Chlorophyll *a* measured by Fluorometric method with acid correction.
S Chlorophyll *a* measured by Spectrophotometric method with acid correction.
T Chlorophyll *a b c* measured by Trichromatic method.
NA Not Applicable

7.4 California NNE Approach

While the USEPA guidance criteria can prove useful for screening purposes, USEPA also noted that States may need to identify with greater precision the nutrient levels that protect aquatic life and recreational uses.

The California nutrient numeric endpoints (NNE) approach was developed as a methodology for the development of nutrient (nitrogen and phosphorus) numeric endpoints for use in the water quality programs of the California's State Water Resources Control Board (State Water Board) and Regional Water Quality Control Boards (Regional Water Boards). The approach provides a methodology to support several water quality program components including: setting numeric limits for National Pollutant Discharge Elimination System (NPDES) permits; development of Total Maximum Daily Load (TMDL) nutrient numeric endpoints; and for those Regional Water Boards that choose to, the development of numeric nutrient criteria (TetraTech, 2006).

The California NNE approach is a risk-based approach in which algae and nutrient targets can be evaluated based on multiple lines of evidence; essentially, the intention of the NNE approach is to use nutrient response indicators to develop potential nutrient water quality criteria. The California NNE approach also includes a set of relatively simple spreadsheet scoping tools[3] for application in lake/reservoir or river systems to assist in evaluating the translation between response indicators (e.g. algal biomass) and nutrient concentrations. These response indicators can be incorporated as targets, which can then be translated into site-specific nutrient targets. Nutrient targets established in this way are supplemental to those established to meet specific numeric criteria, such as water quality criteria for dissolved oxygen.

As noted above, the NNE approach requires the consideration of biological indicators as "response variables" in addition to measurement of nitrogen and phosphorus at representative sections of the stream reach water column. The NNE develops water quality targets for the response variables (e.g., benthic chlorophyll a density and corresponding estimated algal biomass density). These targets determine how much algae can be present without impairing designated beneficial uses. Numeric models (e.g., QUAL2K) are then used to convert the initial water quality targets for the response variables into numeric targets for nutrients. These numeric targets, can be assessed as one line of evidence, and as verified by other metrics (see section 7.5.1), may potentially be utilized in establishing TMDLS for impaired water bodies.

Another important tenet of the California NNE approach (Tetra Tech 2006) is that targets should not be set lower than the value expected under natural conditions. As such, the NNE approach may require multiple lines of evidence, including but not limited to, the use of the NNE spreadsheet scoping tool.

For additional information, narrative from the Calif. NNE Final Report (2006) in provided below (emphasis added):

> "The process for developing nitrogen and phosphorus nutrient criteria for the region started in 1998 with the publication of the U.S. Environmental Protection Agency's *National Strategy for the Development of Regional Nutrient Criteria* (USEPA, 1998). USEPA then **proceeded to**

[3] This spreadsheet tool is referred to interchangeably in this report as the California "Benthic Biomass Tool" or the California "NNE tool".

develop national criteria recommendations based on aggregated Level III ecoregions. Data sets from Legacy STORET, NASQAN, NAWQA, and EPA Region 10 were used by EPA to assess nutrient conditions from 1990 to 1998.

EPA proposed that the 25th percentiles of all nutrient data could be assumed to represent unimpacted reference conditions for each aggregate ecoregion, and also provided a comparison of reference condition for the aggregate ecoregion versus the subecoregions. **These 25th percentile values were characterized as criteria recommendations that could be used to protect waters against nutrient over-enrichment (USEPA, 2000).** However, EPA also noted that States and Tribes may "need to **identify with greater precision** the nutrient levels that protect aquatic life and recreational uses. This can be achieved through development of criteria modified to reflect conditions at a smaller geographic scale than an ecoregion such as a subecoregion, the State or Tribe level, or specific class of waterbodies." USEPA also encouraged that States and Tribes "critically evaluate this information in light of the specific designated uses that need to be protected."

Several researchers have demonstrated the shortcomings of using ambient nutrient concentrations within a waterbody alone to predict eutrophication, particularly in streams (Heiskary and Markus, 2001; Prairie et al., 1989; Welch et al., 1989; Chételat, et al., 1999; Dodds et al., 2002; Fevold, 1998; Van Nieuwenhuyse and Jones, 1996). Ambient concentration data may not be effective in assessing eutrophication and the subsequent impact on water use because algal productivity depends on several additional factors such as morphology, light availability, flooding frequency, biological community structure, etc.

In essence, the California NNE approach:

- Provides technical approach for developing numeric criteria, nutrient numeric endpoints for TMDLS or NPDES discharge limits
- Defines three risk categories for indicators (measures of algal growth and oxygen deficit)
  - Presumably unimpaired
  - Potentially impaired
  - Likely impaired
- Modeling tools links indicators to nutrient concentrations

The modeling tools provided in the California NNE approach includes:"

- Inputs include nutrients, canopy closure, water temperature, latitude, flow velocity and depth
- Predicts biological responses (benthic biomass, benthic chlorophyll, oxygen depletion) using seven different models
- Compares predictions to selected cold and warm water threshold values
  - Benthic biomass > 60 or >80 g/m-2 AFDW
  - Benthic Chlorophyll *a* >150 or >200 mg/m-2

The California NNE approach can essentially be summarized as below:

….it is proposed….that nutrient criteria not be defined solely in terms of the concentrations of various nitrogen and phosphorus species, but also include consideration of primary biological responses to nutrients. It is these biological responses that correlate to support or impairment of uses. It is proposed that the consideration of biological responses be **in addition to** chemical concentrations in the final form of the nutrient criteria (TetraTech, 2004).

Documents pertaining to the California NNE Approach can be downloaded from:

http://rd.tetratech.com/epa/

7.5 Technical Approach to Developing Numeric Targets

7.5.1 General Approaches

USEPA had published technical guidance on developing nutrient criteria for river and streams (USEPA, 2000). A general overview of USEPA's nutrient criteria development process is outlined below:

- Identify water quality goals with regard to managing nutrient enrichment problems. Broadly speaking, water quality goals for this project are tied to the Basin Plan narrative water quality objective for biostimulation, which reads: *"Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growths cause nuisance or adversely affect beneficial uses."*
- Nutrient criteria need to be developed to account for natural variation existing at the regional and basin level. Different waterbody processes and responses dictate that nutrient criteria be specific to waterbody type. No single criterion will be sufficient for each waterbody type.
- With the previous bullet in mind, classify and group streams by type or comparable characteristics (fluvial morphology, hydraulics, physical, biological or water quality attributes). Classification will allow criteria to be identified on a broader scale rather than a site-specific scale.
- Select variables for monitoring nutrients: Variables are measurable attributes that can be used to evaluate or predict the condition or degree of eutrophication in a waterbody. Four primary water quality attributes that must be addressed are TN, TP, chl *a* as an estimate of algal biomass, and turbidity.
- Collect and build database and analyze data: nutrient criteria should relate nutrient concentrations in streams, algal biomass, and changes in ecological conditions (e.g., nuisance algal accrual rate and deoxygenation). In addition, the relative magnitude of an biostimulation problem can be determined by examining total nutrient concentration and chl a frequency distributions for stream classes. These analyses may provide a tool for measuring the potential extent of biostimulation.
- Develop criteria based on reference conditions and data analysis. Criteria selected must first meet the optimal nutrient condition for that stream class and

second be reviewed to ensure that the level proposed does not result in adverse nutrient loadings to downstream waterbodies.

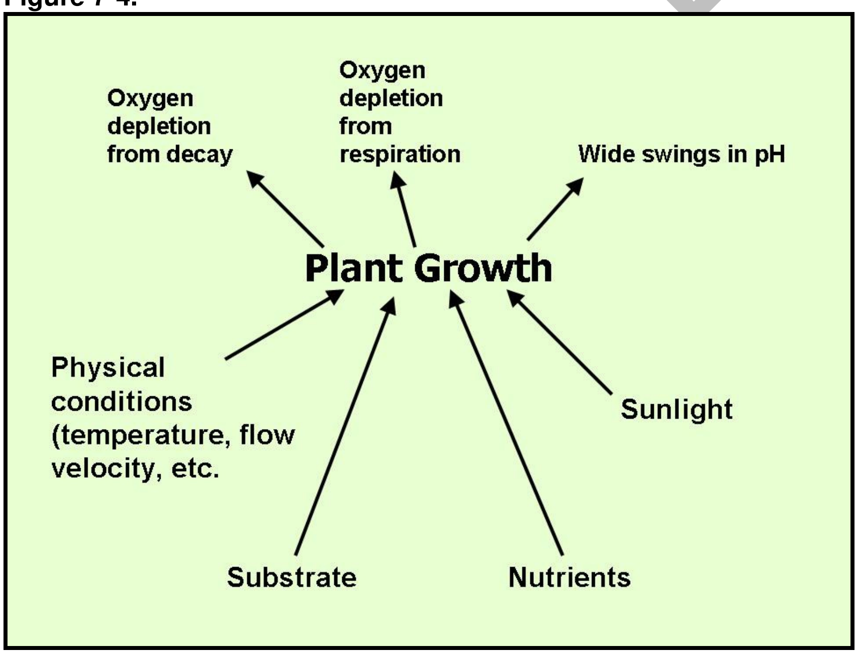
- Three general approaches for criteria setting are discussed by USEPA: (1) identification of reference reaches for each stream class based on best professional judgment or percentile selections of data plotted as frequency distributions, (2) use of predictive relationships (e.g., trophic state classifications, models, biocriteria), and (3) application and/or modification of established nutrient/algal thresholds (e.g., nutrient concentration thresholds or algal limits from published literature).

7.5.2 Measures, Indicators and Targets

The Central Coast Basin Plan has narrative criteria regarding biostimulatory substances, which states: "Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growths cause nuisance or adversely affect beneficial uses." They do not, however, specify what levels of algal growth constitute a nuisance.

The complexity of the biological and physical parameters that affect biostimulation, is illustrated in figure 7-4 below

Figure 7-4.



The California NNE Approach Defines three risk categories for indicators (measures of algal growth and oxygen deficit)

- Presumably unimpaired
- Potentially impaired
- Likely impaired

–

Additional detail on the three risk categories is provided by TetraTech, 2007:

> The California NNE approach recognizes that there is no clear scientific consensus on precise levels of nutrient concentrations or response variables that result in impairment of a designated use. To address this problem, waterbodies are classified in three categories, termed Beneficial Use Risk Categories (BURCs). BURC I waterbodies are not expected to exhibit impairment due to nutrients, while BURC III waterbodies have a high probability of impairment due to nutrients. BURC II waterbodies are in an intermediate range, where additional information and analysis may be needed to determine if a use is supported, threatened, or impaired. Tetra Tech (2006) lists consensus targets for response indicators defining the boundaries between BURC I/II and BURC II/III.

Table 7-1 synthesizes the consensus BURC boundaries for various secondary indicators developed by TetraTech for the California NNE approach. The BURC II/III boundary provides an initial scoping point to establish minimum requirements for a TMDL.

Table 7-1. Nutrient Numeric Endpoints for Secondary Indicators - Proposed Rish Classification Category Boundaries: 1 & II and II & III.

Beneficial Use Risk-Category I. Presumptive unimpaired (use is supported).
Beneficial Use Risk Category II. Potentially impaired (may require an impairment assessment)
Beneficial Use Risk Category III. Presumptive impaired (use is not supported or highly threatened)

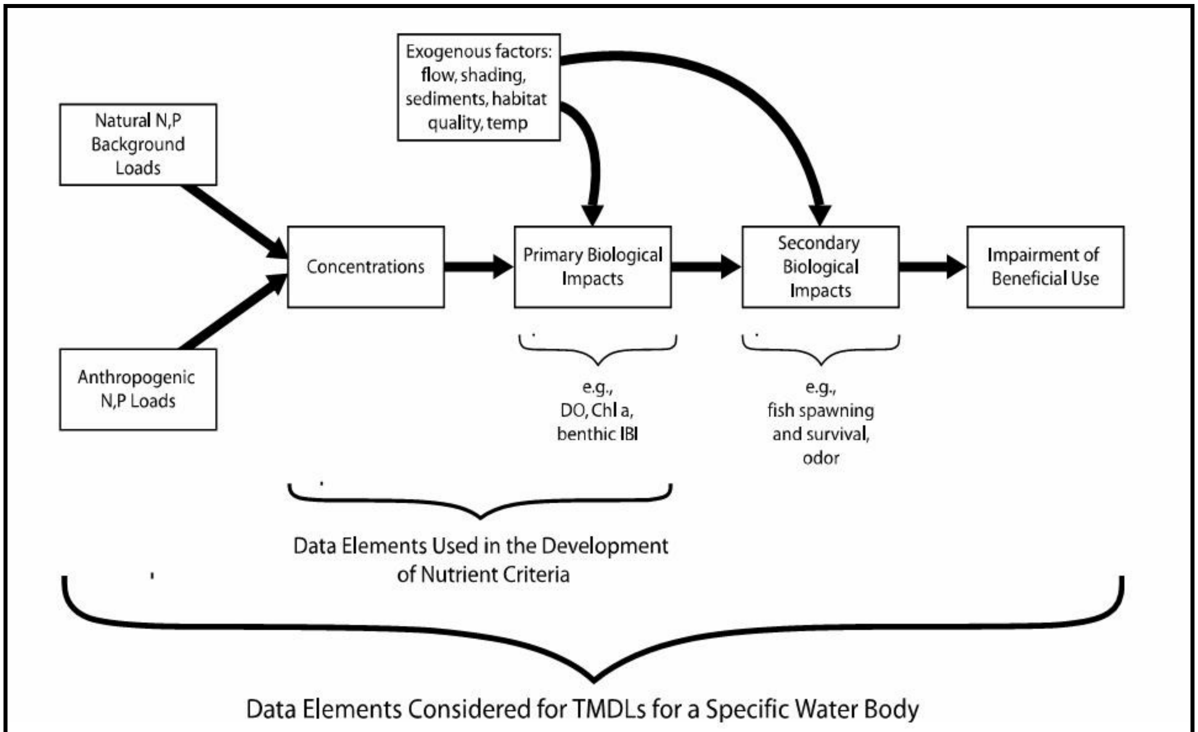
RESPONSE VARIABLE	RISK – CATEGORY BOUNDARY	BENEFICIAL USE						
		COLD	WARM	REC-1	REC-2	MUN[1]	SPWN	MIGR
Benthic Algal Biomass in streams (mg chl-a/m^2)	I / II	100	150	C	C	100	100	B
Maximum	II / III	150	200	C	C	150	150	B
Planktonic Algal Biomass in Lakes and Reservoirs (as µg/L Chl-*a*)[2] – summer mean	I / II	5	10	10	10	5	A	B
	II / III	10	25	20	25	10	A	B
Clarity (Secchi depth, meters.)[3] – lakes summer mean	I / II	A	A	2	2	A	A	B
	II / III	A	A	1	1	A	A	B
Dissolved Oxygen (mg/l) Streams – the mean of the 7 daily minimums	I / II	9.5	6.0	A	A	A	8.0	C
	II / III	5.0	4.0	A	A	A	5.0	C
pH maximum – photosynthesis driven	I / II	9.0	9.0	A	A	A	C	C
	II / III	9.5	9.5	A	A	A	C	C
DOC (mg/l)	I / II	A	A	A	A	2	A	A
	II / III	A	A	A	A	5	A	A

A = No direct linkage
B = More research needed to quantify linkage
C = Addressed by Aquatic Life Criteria

[1] For application to zones within water bodies that include drinking water intakes.
[2] Reservoirs may be composed of zones or sections that will be assessed as individual water bodies
[3] Assumes that lake clarity is a function of algal concentrations, does not apply in waters of high non-algal turbidity

Figure 7-5 illustrates the data elements that should be considered for nutrient TMDL development.

Figure 7-5. Data Elements Considered for Nutrient TMDLs (from TetraTech, 2004).



As noted by TetraTech (2006): "except in extreme cases, nutrients alone do not impair beneficial uses. Rather, they cause indirect impacts through algal growth, low DO, and so on, that impair uses. These impacts are associated with nutrients, but result from a combination of nutrients interacting with other factors. Appropriate nutrient targets for a waterbody should take into account the interactions of these factors to the extent possible. For instance, the nutrient concentration that results in impairment in a high-gradient, shaded stream may be much different from the one that results in impairment in a low-gradient, unshaded stream. The nutrient criteria framework needs to contain, in addition to nutrient concentrations, targeting information on secondary biological indicators such as benthic algal biomass, planktonic chlorophyll, dissolved oxygen, dissolved organic carbon, macrophyte cover, and clarity. These secondary indicators provide a more direct risk-based linkage to beneficial uses than the nutrient concentrations alone. The approach taken for California is to propose nutrient numeric endpoints based on an evaluation of risk relative to designated beneficial uses. Essentially, the objective is to control excess nutrient loads/concentrations to levels such that the risk or probability of impairing the designated uses is limited to a low level. If the nutrients present – regardless of actual magnitude – have a low probability of impairing uses, then water quality standards can be considered to be met."

7.5.3 CCAMP Screening Targets and Reference Sites

The California Central Coast Water Board developed nutrient screening criteria using the California Benthic Biomass Tool for use in the 2008 303(d) Integrated Report that is intended to protect aquatic life beneficial uses from the consequences of excessive nutrient enrichment or "biostimulation." Narrative from the R3 *Technical Approach for Developing California NNE* shown below (emphasis added):

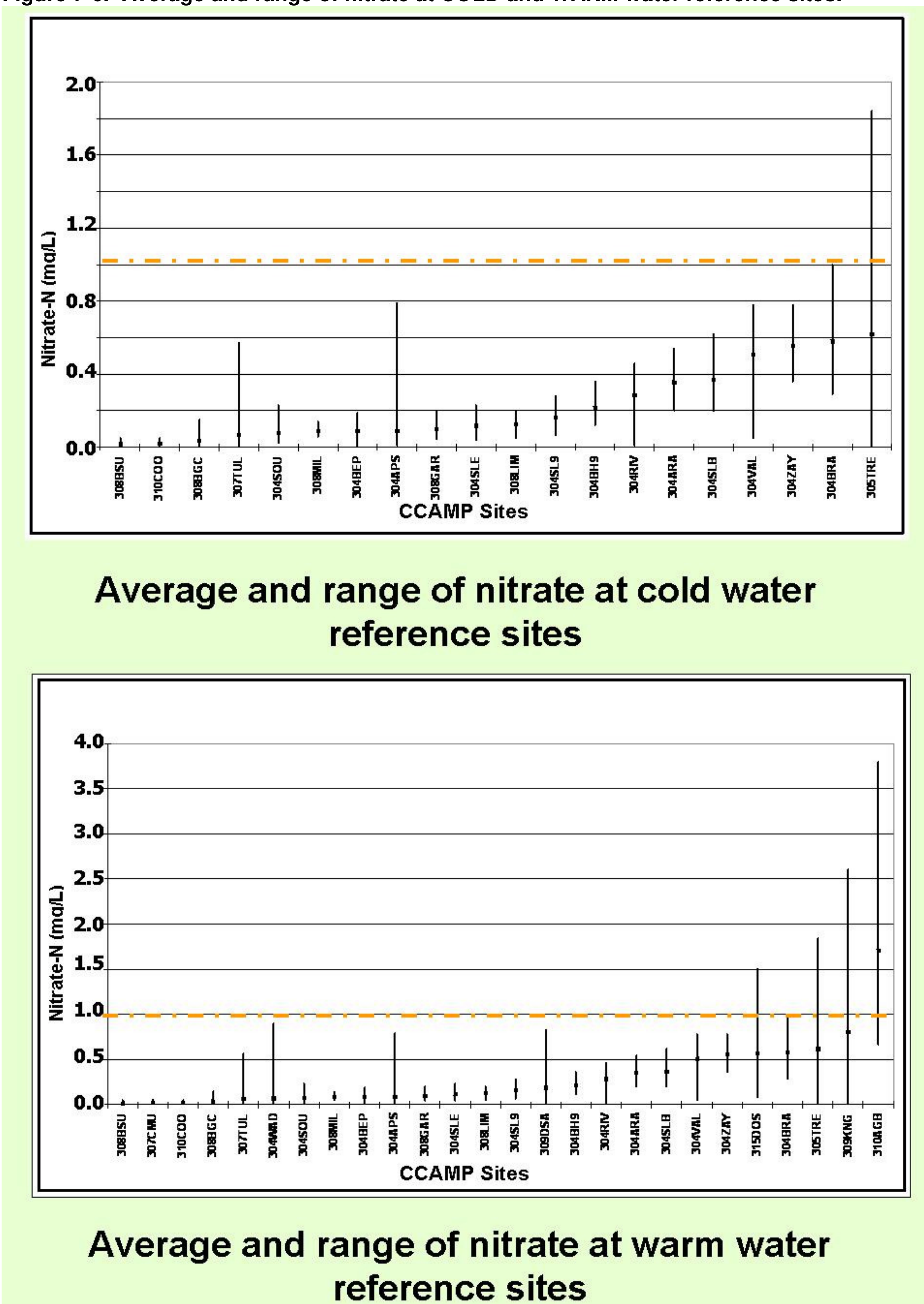
> Central Coast Water Board Application of the California NNE - Central Coast Water Board staff has several goals in utilizing the California NNE for the 2008 303(d)/305(b) Integrated Assessment. The current Basin Plan nitrate criterion is set to protect drinking water for human health purposes. For many years, Central Coast staff has worked with staff from State Board and other Regions to support the development of nutrient criteria and the NNE, to provide us with a tool to protect against biostimulation. CCAMP data was utilized in development of the NNE. The Benthic Biomass Tool is now in place, and it is our goal to screen our highest priority water bodies during the 2008 listing cycle, with the intent of further evaluating this approach over the next two years for development of Basin Plan objectives and for screening of all water bodies for the 2010 Integrated
> Assessment.
>
> Staff submitted CCAMP data (1998 – 2006) for water body minimums, maximums, and means for nitrate, nitrite, ammonia, ortho-phosphate, total phosphorus and water temperature into the California Benthic Biomass Tool. To screen data for probable effects, we utilized the NNE warm water threshold 200 for chlorophyll a and 80 grams/m ash-free dry weight values of 200 mg/m (AFDW) for algal density, and the cold water threshold values of 150 mg/ m for chlorophyll a and 60 grams/m AFDW for algal density. We used default values for other model inputs, including latitude of 35 degrees, canopy cover of 80%, stream velocity of 0.3 meters per second and stream depth of 0.5 meters. Our assumption of a relatively dense canopy cover produces an estimate of probable effects that conservatively identifies problem conditions. Resulting outputs provided estimates of biomass and chlorophyll a production based on input variables, and also estimated oxygen deficit for each water body.

In developing the 2008 303(d) Integrated Report, based on the NNE approach and based on evaluation of central coast water quality data, CCAMP staff identified the following conditions as representative of "reference" sites in Region 3 that showed **no evidence** of biostimulation:

- Dissolved oxygen under 13 mg/L (super saturation upper limit)
- Water column chlorophyll *a* under 15 ug/L
- Filamentous algal cover under 50%

Using these reference sites, CCAMP staff selected a guideline concentration of nitrate of 1 mg/L based on the reference data evaluation (this is the 95th percentile of reference site data), as shown in Figure 7-6.

Figure 7-6. Average and range of nitrate at COLD and WARM water reference sites.



Further, based on recommendations by the USEPA Scientific Advisory Board (2009, 2010) to use a weight of evidence approach that establishes a relationship between nutrients and biological response measure, CCAMP developed a multiple-lines-of-evidence quantifiable approach for identifying nutrient-enriched waterbodies that are impaired for the aquatic life beneficial use. For waterbodies that exceed the aforementioned 1.0 mg/L Nitrate-N criteria, CCAMP designates these waterbodies as impaired when there is also additional evidence of eutrophication, as shown in Table 7-2.

Table 7-2. CCAMP Numeric Criteria for Impairment Due to Nutrient Over-Enrichment.

Parameter	Numeric Criteria	Source of Criteria / Notes
Nitrate-N	1.0 mg/L	CCAMP reference site approach
Floating algal mats	> 50% water surface	CCAMP screening criteria (see NDEP, 2007)
Chlorophyll *a*	>15 mg/L	CCAMP screening criteria for evidence of nutrient over-enrichment (based in part on OAR, 2000, USEPA, 2000, and North Carolina Administrative Code 15 A NCAC 02B .0211 (3) (a)). Central Coast Region has used 40 ug/L as stand-alone evidence to support chlorophyll *a* listing recommendations for the 303(d) Impaired Water Bodies list. However, CCAMP are using 15 ug/L as supporting evidence of nutrient over-enrichment, based on a review of existing and recommended limits used elsewhere.
Evidence of oxygen depression	-Dissolved Oxygen shall not be depressed below 5.0 mg/L. -Median values should not fall below 85% saturation.	Basin Plan Numeric Objective
Evidence of oxygen supersaturation	>13 mg/L	CCAMP screening criteria.
pH maximum (photosynthesis-driven)	>9.5	California NNE Approach BURC II/III target
Predicted oxygen deficits	>1.25 mg/L	Benthic Biomass Tool output.
Downstream Impacts Associated with Excessive Nutrients	Benthic Biomass Tool Outputs	Field conditions, including benthic algal biomass, benthic chlorophyll a concentration and algal contribution to oxygen deficit, may vary considerably from modeled values, depending on a number of variables including stream substrate type, streambed profile, vertical stratification, residence time, absolute temperatures and turbidity. For this reason, field evidence of widely ranging oxygen, pH or excessive algal cover or chlorophyll a concentrations is preferable for confirming impairments to the aquatic life beneficial use. However, modeled outputs also **help characterize risk to downstream environments where site level characteristics may be more conducive to algal growth**, and thus should be included as part of the overall weight of evidence of impairment.*

*USEPA Scientific Advisory Board (2009, 2010) stressed the importance of recognizing downstream impacts associated with excessive nutrients.

In addition to CCAMP's application of the California Benthic Biomass Tool, the spreadsheet tool was also was applied by Tetratech in the Nutrient Numeric Endpoints for TMDL Development: Chorro Creek Case Study Review (2007). The results are shown in Figure 7-7.

Figure 7-7. Chorro Creek Numeric Endpoints for TMDL Development.

Table 4. Summer Nutrient Concentrations to Meet WARM Use Maximum Benthic Chlorophyll *a* Target of 200 mg/m² (80% Canopy Closure)

Station	Standard QUAL2K		Revised QUAL2K		Dodds (2002)	
	Total N (mg/L)	Total P (mg/L)	Total N (mg/L)	Total P (mg/L)	Total N (mg/L)	Total P (mg/L)
310CAN	1.92	0.11	2.9	0.045	0.18	0.016
310TWB	1.67	0.11	2.8	0.044	0.20	0.043

Table 5. Summer Nutrient Concentrations to Meet COLD Use Maximum Benthic Chlorophyll *a* Target of 150 mg/m² (80% Canopy Closure)

Station	Standard QUAL2K		Revised QUAL2K		Dodds (2002)	
	Total N (mg/L)	Total P (mg/L)	Total N (mg/L)	Total P (mg/L)	Total N (mg/L)	Total P (mg/L)
310CAN	0.50	0.029	1.6	0.028	0.085	0.005
310TWB	0.46	0.032	1.6	0.027	0.091	0.012

7.6 Summary of Reference Numeric Targets and NNE Input Parameters

Based on information presented previously in this report, a summary of relevant reference numeric targets for protection against biostimulation developed in the Central Coast region (Ecoregion III, Subecoregion 6) is provided in Table 7-3:

Table 7-3. NNE Reference Numeric Targets Relevant to Ecoregion III, Subecoregion 6.

Source	Watershed/Region	Nature of Nutrient Targets	Total N (mg/L)	Total P (mg/L)	Turbidity (NTU)	Chlorophyll *a* (µg/L)	Areal Coverage of Algae
USEPA (2000)	Central and southern Calif. chaparral and Oak woodland nutrient ecoregion.	**Guidelines:** Regional Guidance Criteria (25th percentile of all ecoregional data)	0.52	0.03	1.9	2.4	N.A.
CCAMP (2006)	Central Coast – Region 3	**Screening Criteria** for 2008 303(d) Integrated Report (95th percentile of CCAMP reference sites)	1.0[A]	N.A.	Assume 0.6	15	N.A.
TetraTech (2007)[B]	Chorro Creek	**Numeric Endpoints** Pilot Study, Chorro Creek TMDL Development (NNE tool results)	2.9 (WARM) 1.6(COLD)	0.045(WARM) 0.028(COLD)	Assume 0.6	N.A.	40%
USEPA (2003)	Malibu Creek	**Numeric Targets** in EPA Established Nutrient TMDL	1.0 Summer 8.0 Winter	0.1	N.A.	N.A.	N.A.
RWQCB – Region 9 (2006)	Rainbow Creek	**Numeric Targets** Rainbow Creek Nutrient TMDL	1.0	0.1	N.A	N.A	N.A

A: Nitrate as N
B: NNE as derived from Revised QUAL2K method. (see California NNE documentation)

Table 7-4 presents the numeric water quality objectives found in the central coast basin plan that pertain to the toxic effects of nutrient compounds.

Table 7-4. Numeric Water Quality Objectives from Basin Plan.

Beneficial Use	Nitrate as N (mg/L)	Un-ionized Ammonia (mg/L)
MUN	10	-
Aquatic Life	-	0.025

While there are no water quality objectives regarding the toxic effects of nitrate on freshwater species, literature values have been reported. With respect to the toxic effects of Nitrate as N in freshwater habitat Camargo et al. (2005) report that a maximum level of 2 mg NO_3-N/l would be appropriate for protecting the most sensitive freshwater species.

As shown in Table 7-9, USEPA developed seasonal nutrient criteria for the Malibu Creek watershed, as shown in the figure below:

Figure 7-8. USEPA Nutrient Criteria for Malibu Creek Watershed TMDL.

EPA stresses that these numeric target values are proposed only for waters in the Malibu Creek watershed. The inclusion of these numeric target values for Malibu watershed is not intended to reflect any judgements about the numeric targets needed for other nutrient TMDLs needed in California.

Table 13. Summary of numeric targets for nitrogen and phosphorus as monthly averages

Waterbody Type	Summer (April 15 to Nov. 15)		Winter (Nov. 16 to April 14)
	Total Nitrogen (mg/l)	Total Phosphorous (mg/l)	Total Nitrogen (mg/l)
Lakes	1.0	0.1	8.0
Streams	1.0	0.1	8.0
Lagoon	1.0	0.1	8.0

e. Basis for Summer Nitrogen and Phosphorus Numeric Targets

Streams At the present time there are no numeric nutrient criteria for general waters of California. States are being asked to develop nutrient criteria and Regional Board 4 staff is participating in the EPA and State work groups to development eco-regional specific nutrient criteria. Although studies are underway in a number of watersheds, the deadline for development and implementation of nutrient criteria is several years away.

EPA concluded that it is necessary to set numeric targets more stringent than the existing numeric objectives for total nitrogen in order to ensure attainment of the narrative objective that addresses Biostimulatory Substances. Our review of available data, studies, and information indicate that the numeric objectives are not sufficiently protective during the summer months when algae problems are most pronounced.

Tetra Tech, Inc. under contract to EPA Region 9 and the California State Water Resources Control Board developed an approach for calculating nutrient numeric endpoints (NNE) for use in California Water Quality Programs (Tetra Tech, 2006). The NNE Benthic Biomass Predictor tool[4] provides a variety of empirical and simplified

[4] The NNE Benthic Biomass Predictor tool is also referred to interchangeably in this report as the "NNE spreadsheet tool".

parametric model approaches to predicting benthic algal response to ambient physical and chemical conditions.

The NNE spreadsheet tool can be used to predict nutrient concentration targets needed to achieve a specified maximum algal density. For the COLD uses, Tetra Tech (2006) recommends that the target for maximum benthic chlorophyll *a* should generally be between 100 mg/m^2 (BURC I/II boundary below which conditions may be deemed acceptable) and 150 mg/m^2 (BURC II/III boundary above which conditions are deemed unacceptable). For the WARM uses, Tetra Tech (2006) recommends a BURC I/II boundary of 150 mg/m^2 and a BURC II/III boundary of 200 mg/m^2. (TetraTech, 2007)

Table 7-5 presents the NNE spreadsheet tool input values recommended in the California NNE approach, and/or as used in previous central coast watershed analyses.

Table 7-5. NNE Parameter Specification in Previous Central Coast Watershed Analyses.

Source	Watershed/Region	Hydraulic Characteristics	Light Extinction Coefficient (calculated from turbidity value – NTU)	Days of Accrual	Canopy Cover	Algal Density: Benthic Chlorophyll *a* (mg/m^2)
CCAMP (2006)	Central Coast – Region 3	Stream Depth 0.5m Stream Velocity 0.3 m/s	Default value: 0.6	80 days	80%[A]	150(COLD) 200(WARM)
TetraTech (2007)	Chorro Creek	Stream Depth 0.3m Stream Velocity 0.06 to 0.08 m/s	0.6 (median NTU estimated for Chorro Creek)	Up to 6 months[B]	80%	150(COLD) 200(WARM)

A: CCAMP's assumption of a relatively dense canopy cover produces an estimate of probable effects that conservatively identifies problem conditions.
B: In the California Central Coast Region days of accrual, with increasing algal cover is strongly correlated to days since the winter high flow period. The relationship posed by Biggs, however, appears ill-suited for many California coastal streams, in which the median flow may be very close to summer base flow. Instead, it is more appropriate to evaluate the time between flows of scouring potential – regardless of their relationship to median flow. True scouring flows are most likely to occur during the winter rainy season, and are rare or non-existent during the summer. For evaluation of maximum potential benthic algal growth, in late summer limitation by scouring flows cannot be counted upon, and an appropriate measure of days of accrual appears to be on the order of 6 months (TetraTech, 2007).

8 PROVISIONAL NUTRIENT TARGETS FOR THE LOWER SALINAS NUTRIENT TMDL

This section develops and presents draft provisional numeric targets for nutrients for the Lower Salinas River Watershed Nutrient TMDL.

8.1 NNE Benthic Biomass Predictor Tool Input Parameters

A summary of reference nutrient criteria was outlined in Table 7-2 of the previous section.

While these numeric criteria provide useful guidance, for this project, staff anticipates that numeric endpoints will be developed on the basis of project area subwatershed and waterbody specific physical parameters. The project area comprises a geographically large area, with significant variability in stream morphology, waterbody hydraulics, and physical characteristics. Staff provisionally presumes that one uniform nutrient target will not be sufficient or appropriate in light of the regional variations noted above.

The published USEPA nutrient criteria for ecoregion III, subecoregion 6 were presented previously (0.52 TN and 0.03 TP, mg/L). USEPA notes that these criteria represent a set of *starting points* for States and Tribes to use in establishing their own criteria in standards to protect uses.

CCAMP (2006) provided screening criteria of 1 mg/L nitrate as N for the 2008 303(d) Integrated Report. This value was based on the 95th percentile of CCAMP reference sites. Staff reviewed the CCAMP WARM reference streams; they generally appear to be lower order streams, with relatively higher canopy and shading, and channel morphologies that are not broadly representative of stream reaches in the project area. In particular the CCAMP reference sites may not be representative of ambient hydraulic and physical conditions for valley floor streams, sloughs, and water conveyance structures which are typical of the Salinas Valley.

There are several technically acceptable ways to develop nutrient criteria. For example, based on information provided previously in this report, nutrient criteria may be developed by:

1) USEPA's percentile-based approach: the 25th percentile of nutrient data from appropriate reference streams, or the 75th percentile of all nutrient data for project area stream reaches.
2) Develop nutrient numeric endpoints by predicting benthic algal response to ambient physical and chemical conditions; e.g. the California NNE approach using the NNE spreadsheet tool.

In either case, calculated or estimated nutrient targets should be supplemented and supported with additional data elements, as shown previously in Figure 7-5.

Accordingly, in this section staff present *provisional and preliminary* numeric targets for nutrients calculated using the NNE Benthic Biomass Predictor tool. The NNE Benthic Biomass Predictor tool provides a variety of empirical and simplified parametric model approaches to predicting benthic algal response to ambient physical and chemical conditions. As outlined in the previous section, this spreadsheet tool has been used to develop numeric endpoints and screening criteria for nutrients in the Central Coast region. Spreadsheet NNE input parameters used in the aforementioned studies were outlined in Table 7-4. These input parameters include water quality data as well as stream hydraulic characteristics (velocity, depth), light penetration (function of turbidity), canopy cover, and days of accrual.

Staff concludes that while the NNE spreadsheet tool input parameters outlined in Table 7-4 are useful guidance and comparison, staff will not rely on them, or duplicate them as

NNE input parameters for the current project. Furthermore, USEPA guidance (2000) also stresses the importance of taking into account stream morphology, stream classification, and stream hydrology in developing nutrient targets. USEPA explicitly recommends that

> ….nutrient criteria need to be developed to account for natural variation existing at the regional and basin level. Different waterbody processes and responses dictate that nutrient criteria be specific to waterbody type. *No single criterion will be sufficient for each waterbody type.* (USEPA, 2000)

USEPA further recommends classifying and grouping streams by type or comparable characteristics (fluvial morphology, hydraulics, physical, biological or water quality attributes). Classification will allow criteria to be identified on a broader scale rather than a site-specific scale.

With the above USEPA guidance in mind, it should be noted that the project area has a wide range of hydrologic and hydraulic conditions which should, to the extent feasible, be considered in nutrient criteria development. NNE input parameters should be developed with information about site-specific or waterbody-specific conditions, such as hydraulic conditions, stream morphology, riparian shading, water temperature, etc. The aforementioned CCAMP NNE effort largely relied on spreadsheet default values and some assumptions in order to derive regional screening-level estimates. This approach was appropriate for a regional screening analysis. However, these default spreadsheet tool values and assumptions may not be applicable to project area waterbodies.

Further, The TetraTech Chorro Creek Benthic Biomass Tool input parameters (from Table 7-4) are specific to the physical and hydraulic conditions of a discrete stream reach of which may or may not be applicable to project area water bodies.

Figure 8-1 through 8-4 illustrate that there is wide variability in stream morphology, hydraulics, and tree canopy throughout the Lower Salinas River watershed project area. Stream classification in the project area range from ephemeral lower order head water streams, to higher order valley floor rivers, to perennial sloughs, to water conveyance structures such as canals, and agricultural ditches (CCoWS, 2004). Mean annual stream velocity is variable throughout the project area as shown in Figure 8-3 (data source: NHDplus spatial dataset, stream attribute = MAVELU). Tree canopy and shading can vary from zero percent, particularly along coastal sloughs and water conveyance structures, to significantly higher in other types of water bodies (see Figure 8-4 – data source, NLCD 2001 canopy raster). Collectively, these observations indicate that a uniform set of default NNE spreadsheet input parameters, as was used in the CCAMP screening analysis (2006), would be inappropriate for TMDL development for the project area.

As such, in this report staff will provisionally develop NNE spreadsheet parameter specifications that, to the extent feasible, are appropriately reflective of hydraulic and physical conditions of project area-specific water bodies.

Figure 8-1. Reclamation Canal Watershed Stream Classification (Figure: CCoWS, 2004).

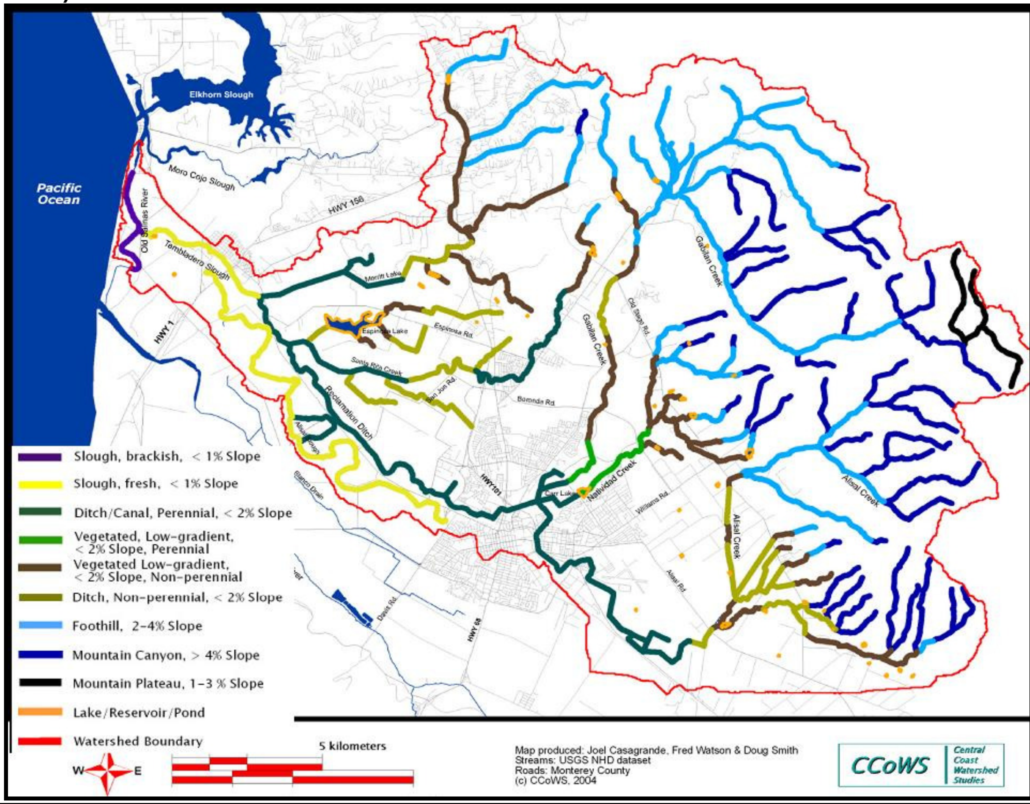


Figure 8-2. Project Area Strahler Stream Order Classification.

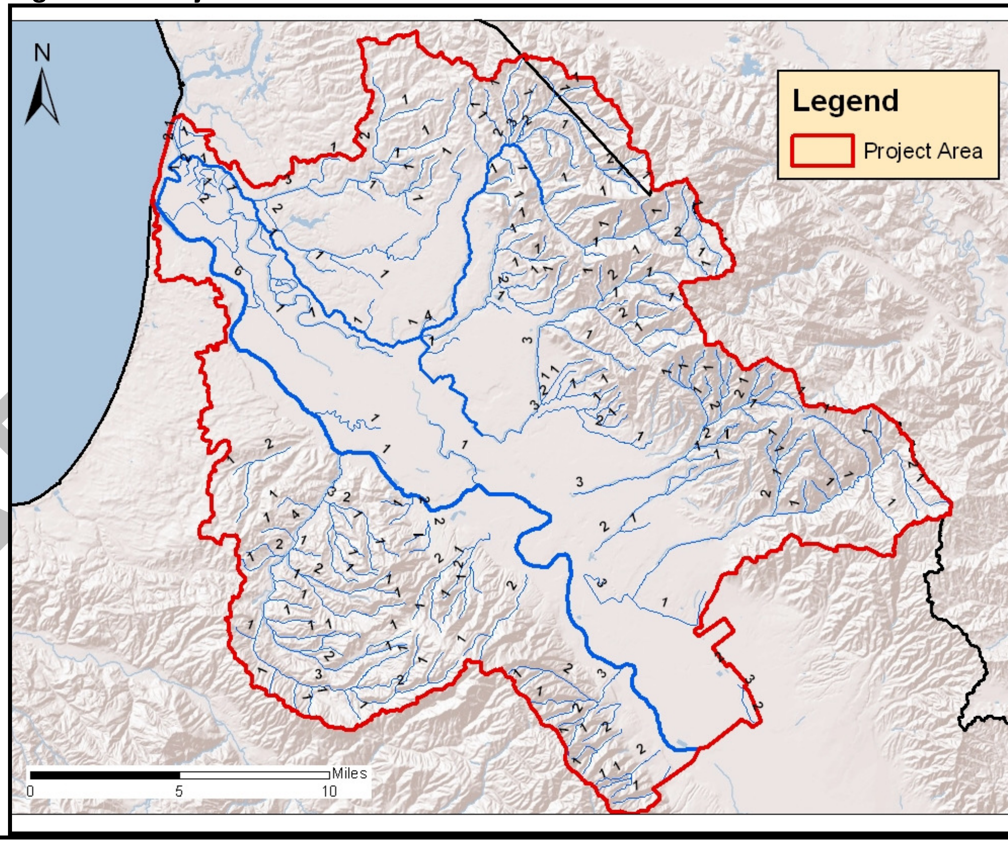


Figure 8-3. Project Area Mean Annual Stream Velocity (source NHD plus)

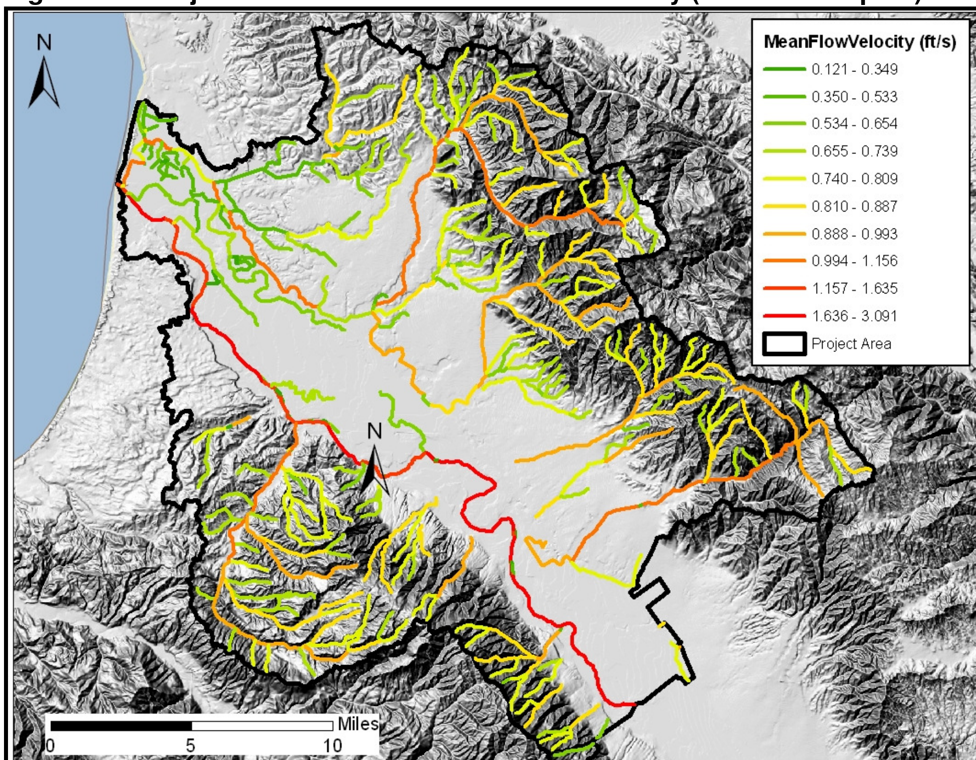


Figure 8-4. Project Area Percent Canopy.

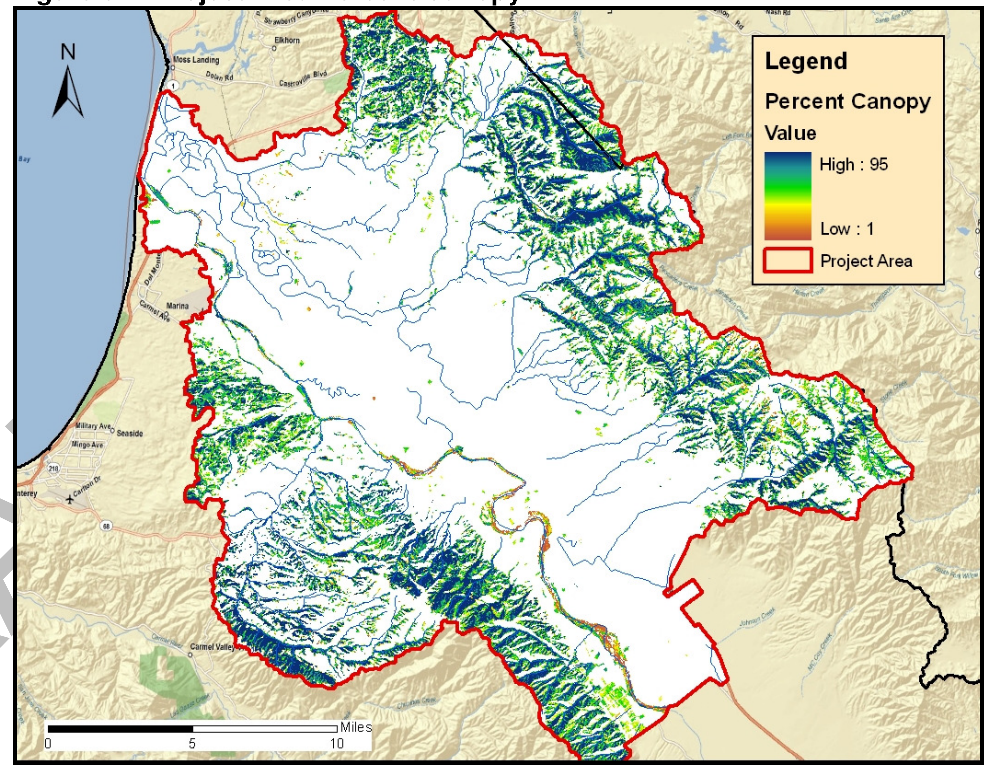


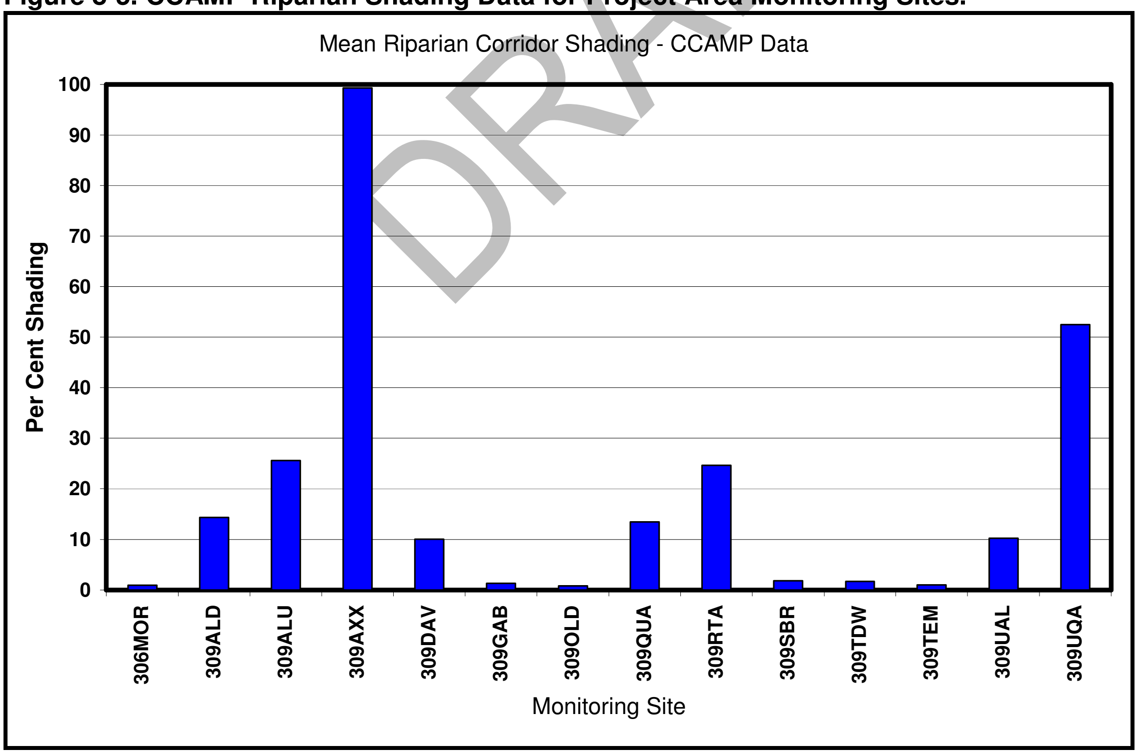
Table 8-1 compiles or estimates various hydraulic and physical parameters for project area stream reaches. The parameters are necessary for input into the NNE spreadsheet tool. Riparian shading estimates in Table 8-1 are from a regional NLCD raster (2001); available at http://www.mrlc.gov/. It is presumed that mean riparian canopy is a plausible surrogate for percent shading. To obtain these estimates, 60 meter buffers around representative stream reaches were used to mask and clip the canopy raster data. The clipped canopy data was used to derive an approximation of the mean amount of canopy in the riparian corridors. Figure 8-5 compiles CCAMP data for estimates of riparian corridor shading at specific monitoring sites. These site-specific data can be used for comparative purposes to the stream reach-level canopy data shown in Table 7-5.

Table 8-1. Estimated Hydraulic and Physical Parameters for Project Area Stream Reaches.

Waterbody	Stream Depth (m)[A]	Mean Summer Water Temp[B] (C)	Tree Canopy in Representative Stream Reaches*	
			Area-Weighted Mean Canopy[C] (%)	*Strahler Stream Order(s)
Gabilan Creek	0.5	17	19.5%	3 to 4
Old Salinas River	1	19	0.4%	4
Salinas Lagoon	1	ND	5.7%	6
Salinas River	1	20	13.5%	6
Chualar Creek	0.5	ND	12.8%	2 to 3
Quail Creek	0.5	19	26.6%	2 to 3
Esperanza Creek	0.5	ND	5.8%	1 to 2
Natividad Creek	0.5	ND	5.7%	2 to 3
Alisal Creek	0.5	17	7.6%	2 to 3
Santa Rita Creek	1	20	1.7%	1 to 2
Reclamation Canal	1	20	0%	4
Alisal Slough	0.5	ND	0.02%	1 to 2
Blanco Drain	1	ND	0.2%	1 to 2
Tembladero Slough	1	19	0.15%	1 to 4

A: assumed depth
B: CCAMP monitoring data 199-2006, summer temps (May-Sept.) only
C: Raster canopy data from NLCD (2001).

Figure 8-5. CCAMP Riparian Shading Data for Project Area Monitoring Sites.

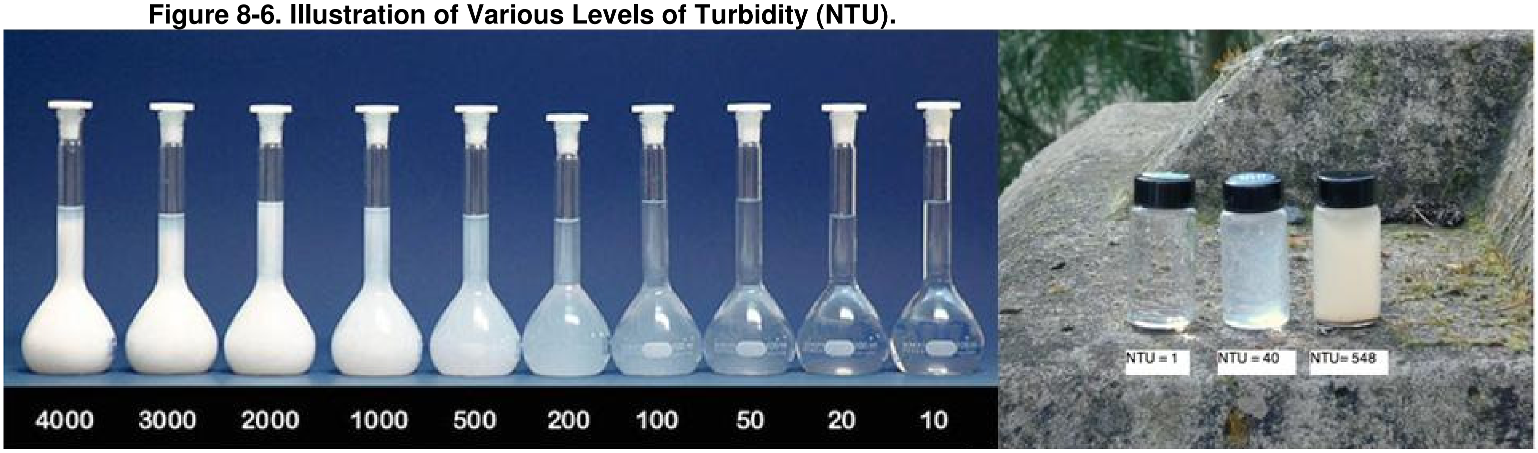


Shading, an input parameter in the NNE spreadsheet tool can be specified in 20 percentile increments – 0%, 20%, 40%, 60%, or 80%. As can be seen from Table 7-5 and Figure 7-11, coastal sloughs and canals, ditches, and channelized stream reaches typically have minimal shading or canopy – close to zero percent. The lower Salinas River appears to have modestly more canopy and shading; consequently the 20% shading value in the NNE spreadsheet tool may plausibly be selected. Shading and canopy in lower order tributary stream reaches appears to be highly variable, but the data in Table 7-5 and Figure 7-11 suggest that canopy or shading are typically significantly 20% or less; consequently the 20% shading value in the NNE spreadsheet tool may plausibly be selected for these waterbodies.

The light extinction coefficient is an important input parameter to the NNE spreadsheet tool. This coefficient is calculated in the spreadsheet as a function of turbidity. The default value in the NNE spreadsheet tool is 0.6 NTU. The USEPA (2000) ecoregional criteria (Ecoregion III-6) for turbidity in reference conditions is 1.9 NTU. Both of these values (0.6 NTU and 1.9 NTU) represent ambient conditions in relatively undisturbed reference streams. Figure 8-6 illustrates the appearance of water with ~1 NTU turbidity, and other ranges of turbidity.

Staff at this time provisionally maintains that aforementioned turbidity reference values (NNE default turbidity value, USEPA ecoregion III-6 reference turbidity value) may not necessarily be reflective of what could be considered to be ambient, relatively undisturbed turbidity conditions in project area waterbodies. Temporal and spatial variation in ambient water quality is anticipated to occur throughout the project area as a result of the high variability in hydrology, hydraulics, and stream reach morphology. As noted previously, the project area of the Salinas Valley floor encompasses sloughs, higher order valley floor rivers, and water conveyance structures such as canals and ditches. Constructed or modified water conveyance structures typically may have substrates composed of bare earth which add suspended solids to the water column via erosion. Higher order alluvial valley floor rivers may carry higher densities of suspended solids, as compared to lower order stream reaches draining middle to upper watershed areas which are potentially comprised of outcropping bedrock or coarser grained materials.

Figure 8-6. Illustration of Various Levels of Turbidity (NTU).



Therefore, staff compiled CCAMP data for turbidity in project area stream reaches in order to assess spatial variation in turbidity data. Modest variances in the turbidity value parameter (light extinction coefficient) can result in significant differences in numeric target results in NNE. In accordance with the USEPA nutrient criteria guidance (2000), staff calculated the 25th percentile of turbidity data for all Salinas River turbidity data (result = 9.7 NTU), and also the 25th percentile of all turbidity data for valley floor sloughs, canals, and ditches (result = 16 NTU). In accordance with the USEPA guidance, staff presumes the 25th percentile of the turbidity data represents relatively undisturbed, ambient water quality conditions.

Additionally, to represent ambient and relatively undisturbed conditions in lower order streams (i.e., tributary stream reaches draining upper watershed areas) staff used USEPA's 25th percentile ecoregional criteria of 5.2 NTU from the central California valley ecoregion (Ecoregion III, subecoregion 1). The second and third order tributary stream reaches in the project area are largely alluvial, agricultural valley floor waterbodies. It is presumed by staff that USEPA's reference turbidity values from the central California Valley ecoregion (ecoregion I-7) are plausibly more representative of these Salinas valley floor water bodies, than are the reference turbidity value from the aggregate California chaparral and oak woodlands ecoregion (ecoregion III-6). Both the Salinas Valley and the Central Valley are characterized by alluvial streams, canals, and water conveyance structures. Staff provisionally maintains these assessed ambient NTU levels are more plausible for project area stream reaches, than the default value provided in the NNE spreadsheet tool of 0.6 NTU. A summary of selected reference turbidity values are presented in Table 8-2. For illustrative purposes, refer back to Figure 8-5 to view what these levels of turbidity (9.7, 16, and 5.2) would approximately look like. To reiterate, staff provisionally maintains that these estimated turbidity reference values are more plausible for project area waterbodies than the Benthic Biomass Tool default turbidity value of 0.6 NTU.

Table 8-2. Selected Reference Turbidly Values for Project Area Waterbody Types.

Waterbody Type	Project Area Examples	Reference Turbidity Value (NTU)	Source of Reference Turbidity Value
Sloughs, Canals, Ditches	Old Salinas River, Reclamation Canal, Alisal Slough, Moro Cojo Slough, Santa Rita Creek	16	25th percentile of turbidity data from project area stream reaches classified as sloughs, canals, and ditches.
6th Order valley floor river: Salinas River	Lower Salinas River	9.7	25th percentile of all Salinas River turbidity data
2nd and 3rd order alluvial valley floor tributary streams	Gabilan Creek, Natividad Creek, Quail Creek, Chualar Creek	5.2	USEPA reference turbidity conditions for central California valley ecoregion. (see narrative in report for explanation)*

* source: USEPA, 2001. Ambient Water Quality Criteria Recommendations – Rivers and Streams in Nutrient Ecoregion I. EPA 822-B-01-012. See Table 3b.

Note: Stream Order classification based on Strahler Stream Order attribute in HHDplus hydrography spatial dataset.

Note that currently, staff provisionally determined that aquatic habitat nutrient targets may not need to be developed for upper watershed first-order streams (Strahler classification). A map of Strahler Order streams was shown in Figure 8-2. Lower order headwater stream reaches typically occur in areas of greater canopy cover (and presumably less sunlight), steep topographic gradients (greater stream and scouring velocity), land cover with typically low risk of nutrient loads (forest and grassland), and being ephemeral reaches are mostly dry in the summer months (refer back to Figures 3-4, 8-2 and 8-3). Provisionally, it is presumed that these low order, head water reaches are at low risk for biostimulation. In contrast, Strahler first order waterbodies on the alluvial valley floor are typically canal, ditch, or water conveyance structures which may have perennial flow and as such, may be classified in the "sloughs, canals, and ditches" hydraulic group in Table 8-2.

In general, staff used the NNE spreadsheet tool default inputs for stream velocity and stream depth, with one exception. The lower Salinas River, and the perennial coastal slough and valley floor canals are presumed to have a water depth of 1 meter, while lower order tributary stream reaches are presumed to have a depth of 0.5 meters. Mean temperature for each of the three groups of project area waterbody types (tributaries; Salinas River; canals/sloughs/ditches) were calculated from CCAMP data. The final Benthic Biomass Tool parameter specifications are presented in Table 8-3.

Table 8-3. Benthic Biomass Tool Parameter Specification for Selected Project Area Stream Reaches.

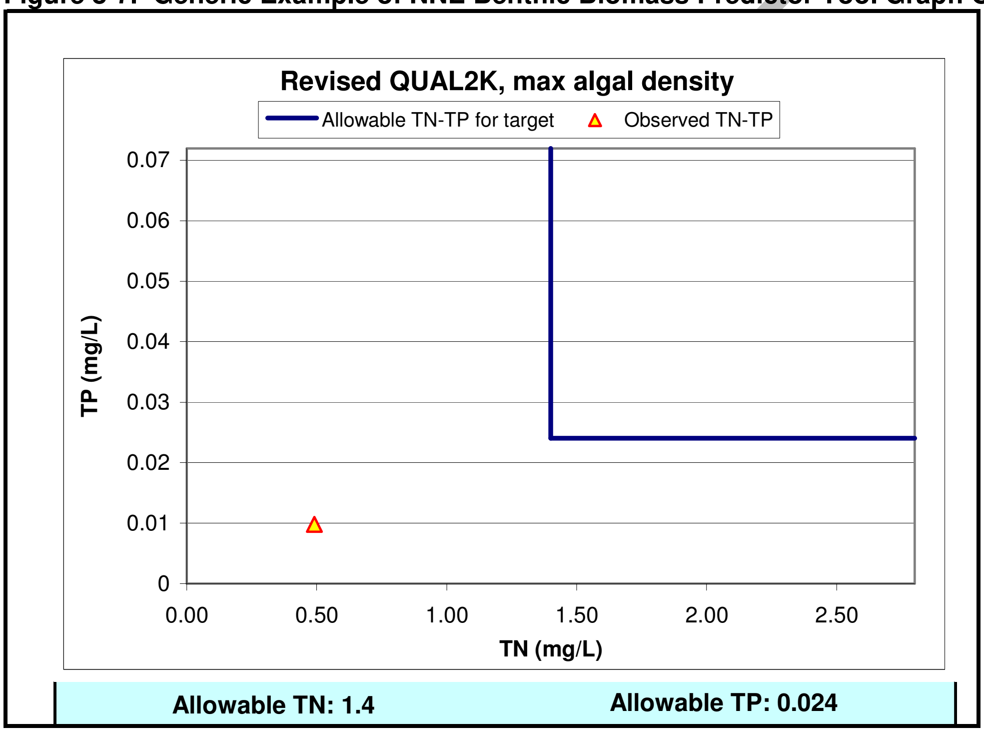
Waterbody Type	Stream Reaches	Mean Velocity (m)	Mean Depth (m)	Mean Temperature (C)	Turbidity (NTU)	Mean Shading (%)	Algal Density Target: Benthic Chlorophyll *a* (mg/m^2)
High Order Stream Reach alluvial valley floor main stem perennial river	Lower Salinas River	0.3	1	20	9.7	20%	150(COLD)
Tributaries – lower order alluvial stream reaches	Gabilan Creek	0.3	0.5	19	5.2	20%	200(WARM)
Canals, Ditches, Sloughs	Old Salinas River,	0.3	1	19	16	0%	150(COLD)
	Reclamation Canal	0.3	1	19	16	0%	200(WARM)

8.2 NNE Benthic Biomass Predictor Tool Results

The NNE Benthic Biomass Predictor tool is a Microsoft Excel spreadsheet, and is intended to be a simple but effective tool for predicting in-stream benthic biomass and other metrics in response to a number of inputs. The tool calculates both algal density under average conditions and benthic chlorophyll *a*. Both are estimated using a variety of methods. The user guide and documentation was provided by TetraTech (2007).

The spreadsheet tool provides the graph of maximum allowable TN and TP according to the selected numeric target and estimation method. The blue line shows the threshold above which the combination of TN and TP is estimated to result in a violation of the target. For illustrative purposes in Figure 8-7 shows a graph was calculated using a QUAL2K method; note that QUAL2K calculates fixed thresholds, reflected by the linear relationships shown in the graph.

Figure 8-7. Generic Example of NNE Benthic Biomass Predictor Tool Graph Output.



8.3 Draft Provisional Numeric Targets – Lower Salinas River Watershed

Using the spreadsheet input parameters developed in Section 8.1, and utilizing the Revised QUAL2K, benthic chlorophyll *a* method and target selection, staff provides the maximum allowable TN and TP as calculated by Benthic Biomass Predictor tool in Table 8-4. The draft numeric targets are protective against the risk of biostimulation.

The NNE spreadsheet results are presented in Figures 8-8 and 8-9. **Note that these numeric targets are provisional in nature, and may be subject to revision.**

Additionally, a summary of all numeric targets for nutrients, and nutrient-related parameters, are presented in Table 8-5. This table compiles all relevant numeric targets based on both the NNE results and on numeric water quality objectives found in the Basin Plan.

Table 8-4. Draft PROVISIONAL Numeric Targets for Biostimulatory Substances: Total Nitrogen and Total Phosphorus.

Waterbody Type	Aquatic Habitat	Project Area Stream Reaches	Allowable Total Nitrogen (mg/L)	Allowable Total Phosphorus (mg/L)	Target Algal Density in Streams (Benthic Chl a – mg/m^2)
Lower Order alluvial valley floor tributary streams (e.g., 2nd and 3rd Stahler Order)	WARM	Alisal Creek Chualar Creek Esperanza Creek Gabilan Creek Natividad Creek Quail Creek	**1.6**	**0.0265**	**200**
6th Order alluvial valley floor river: Salinas River	COLD	Lower Salinas River – Gonzalez to Salinas River Lagoon	**1.4**	**0.0245**	**150**
Sloughs, Canals, Ditches	WARM	Alisal Slough Blanco Drain Espinosa Slough Moro Cojo Slough Merrit Ditch Salinas Reclamation Canal Santa Rita Creek Tembladero Slough	**2.2**	**0.035**	**200**
Sloughs, Channels	COLD	Old Salinas River	**1.4**	**0.0245**	**150**
Lagoons and Lakes[A]	COLD	Salinas River Lagoon Lake Espinosa	**pending**	**pending**	**pending**

A: Numeric targets will be developed, if and as appropriate, for project area lagoons or lakes, using USEPA and California NNE Guidance.

Figure 8-8. Benthic Biomass Predictor Tool Output.

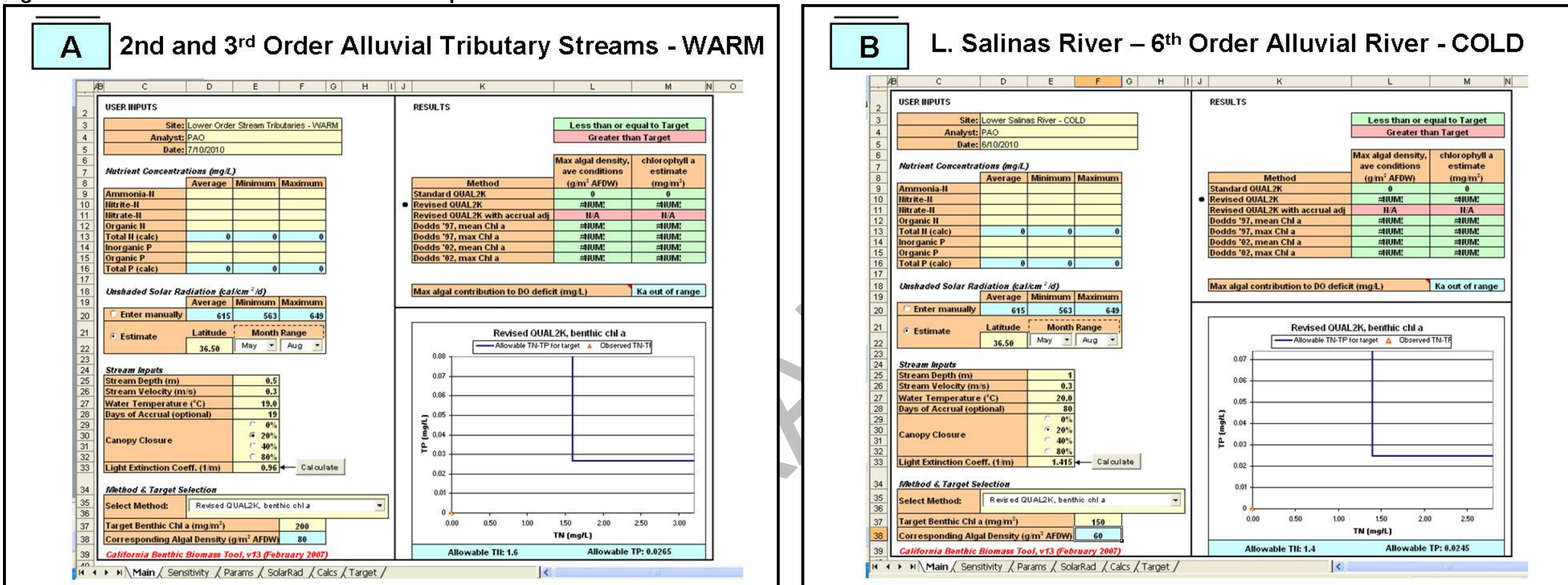
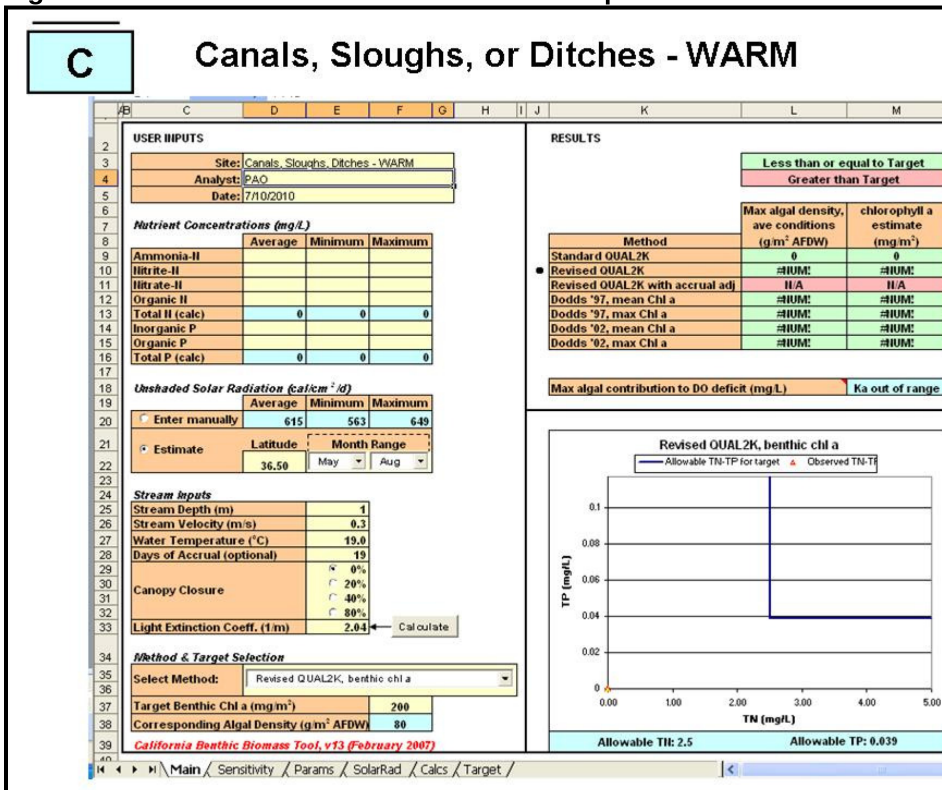


Figure 8-9. Benthic Biomass Predictor Tool Output.



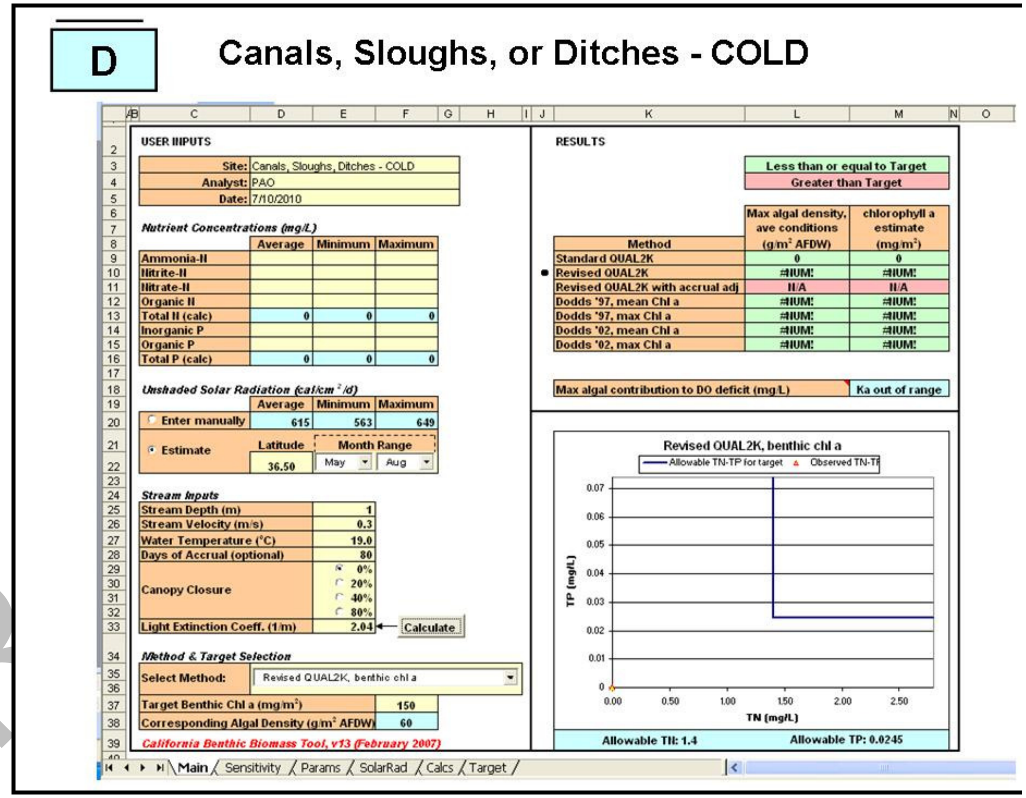


Table 8-5. Compilation of All Numeric Targets for Nutrients and Nutrient-Related Parameters.

<table>
<tr><th>Constituent / Parameter</th><th>Source of WQ Objective</th><th colspan="2">Numeric Target</th><th>Primary Use Protected</th></tr>
<tr><td>Unionized Ammonia as N</td><td>Basin Plan numeric objective</td><td colspan="2">0.025 mg/L</td><td>General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries (toxicity objective)</td></tr>
<tr><td>Nitrate as N</td><td>Basin Plan numeric objective</td><td colspan="2">10 mg/L</td><td>MUN, GWR</td></tr>
<tr><td>Nitrate (NO3) + Nitrite (NO2)</td><td>Basin Plan numeric objective</td><td colspan="2">100 mg/L</td><td>AGR (livestock watering)</td></tr>
<tr><td>Nitrite (NO2)</td><td>Basin Plan numeric objective</td><td colspan="2">10 mg/L</td><td>AGR (livestock watering)</td></tr>
<tr><td>Dissolved Oxygen</td><td>Basin Plan numeric objective</td><td colspan="2">Dissolved Oxygen shall not be depressed below 5.0 mg/L.
Median values should not fall below 85% saturation.</td><td>General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries.</td></tr>
<tr><td>pH</td><td>Basin Plan numeric objective</td><td colspan="2">pH not depressed below 7.0 or raised above 8.5</td><td>General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries.</td></tr>
<tr><td rowspan="3">Biostimulatory Substances

(see NNE results, Table 8-5 for detail)</td><td rowspan="3">Basin Plan narrative objective:

“Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.” (Basin Plan, Chapter 3)</td><th>Total N</th><th>Total P</th><td rowspan="3">General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries (biostimulatory substances objective) -- (e.g., WARM, COLD, REC, WILD, EST)</td></tr>
<tr><td>1.6-2-2 mg/L (WARM)</td><td>0.026-0.035 (WARM)</td></tr>
<tr><td>1.4 mg/L (COLD)</td><td>0.024 mg/L (COLD)</td></tr>
</table>

8.3.1 Alternative NNEs Based on Changes in Canopy Shading

The amount of canopy closure (shading) in a given stream reach can have significant influence on the allowable nutrient concentration calculations of the NNE spreadsheet. This is because the amount of shading in a stream reach can have significant influence on temperature, photosynthesis, and other factors that may promote biostimulation or eutrophication. The draft provisional nutrient targets presented in the previous section are based on approximations of current average canopy cover for higher order stream reaches at the subwatershed scale. As outlined previously, these estimations are based on CCAMP monitoring site field observations; analysis of satellite data of average riparian canopy cover at the stream reach/subwatershed scale; and best professional judgment.

Canopy conditions or estimations may change as a result of more refined stream reach-specific field information, or due to future watershed restoration projects. As such, for informational purposes, additional nutrient targets are presented in Table 8-6 for a range of variations of plausible canopy cover scenarios in project area stream reaches.

Table 8-6. . Allowable Nutrient Concentrations for Various Canopy Scenarios (units=mg/L).

Waterbody Type	Stream Reaches	80% canopy		40% canopy		20% Canopy		0% canopy	
		TN	TP	TN	TP	TN	TP	TN	TP
Lower order alluvial valley floor tributary streams (WARM)	Gabilan Creek, Natividad Creek, Quail Creek, Chualar Creek, Esperanza Creek	6.0	0.088	2.2	0.035	1.6	0.0265	-	-
6th Order valley floor river: Salinas River (COLD)	Lower Salinas River	-	-	2.5	0.044	1.4	0.0245	-	-
Sloughs, Canals, Ditches (WARM)	Reclamation Canal, Alisal Slough, Moro Cojo Slough, Santa Rita Creek, Tembladero Slough	-	-	-	-	5.4	0.08	2.2	0.035
Sloughs (COLD)	Old Salinas River	-	-	-	-	3.1	0.048	1.4	0.0245

(orange)	= baseline, estimated existing reference conditions.
(green)	= increased canopy closure/riparian shading conditions.

*Calculations assume constant turbidity, temperature in all canopy scenarios; however, turbidity and temp could vary with increased tree canopy.
Note: This table provides these data for informational purposes only.

8.4 Nutrient Criteria Development: Additional Lines of Evidence

In USEPA (2000) nutrient criteria guidance for streams, three general approaches for criteria setting are recommended:

(1) Statistical analysis of data: identification of reference reaches for each stream class based on best professional judgment or percentile selections of data plotted as frequency distributions;

(2) use of predictive relationships (e.g., trophic state classifications, models, biocriteria); and
(3) application and/or modification of established nutrient/algal thresholds (e.g., nutrient concentration thresholds or algal limits from published literature).

USEPA (2000) notes that a weight of evidence approach that combines **any or all of the three approaches above will produce criteria of greater scientific validity.**

The NNE approach used in this report may require multiple lines of evidence, including but not limited to, the use of the NNE spreadsheet scoping tool. In developing this report, staff assessed both published nutrient concentration threshold criteria (USEPA, Ambient Water Quality Criteria Recommendation, Rivers and Streams in Nutrient Ecoregion III, 2000); staff also utilized the Benthic Biomass Predictor Tool (California NNE approach) to develop draft nutrient targets.

Also, an important tenet of the California NNE approach (Tetra Tech 2006) is that targets should not be set lower than the value expected under natural conditions As such, an additional line of evidence to support the development of TMDL numeric targets in this report was assessed by an application USEPA's percentile-based selection approach, as outlined below.

EPA's Technical Guidance Manual for Developing Nutrient Criteria for Rivers and Streams (2000) describes two ways of establishing a reference condition. One method is to choose the upper 75th percentile of a reference population of streams. The 75th percentile was chosen by EPA since it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility. With regard to identifying reference streams USEPA defines a reference stream *"as a least impacted waterbody within an ecoregion that can be monitored to establish a baseline to which other waters can be compared. Reference streams are not necessarily pristine or undisturbed by humans."*

USEPA proposed that the 75th percentiles of all nutrient data of these reference stream(s) could be assumed to represent *unimpacted reference conditions* for each aggregate ecoregion, and also provided a comparison of reference condition for the aggregate ecoregion versus the subecoregions.

Alternatively, when reference streams are not identified, the second method USEPA recommends is to determine the lower 25th percentile of the population of *all streams within a region.* The 25th percentile of the entire population was chosen by EPA to represent a surrogate for an actual reference population. To further clarify this point, USEPA (2000) reports that *"(d)ata analyses to date indicate that the lower 25th percentile from an entire population roughly approximates the 75th percentile for a reference population (see case studies for Minnesota lakes in the Lakes and Reservoirs Nutrient Criteria Technical Guidance Document [U.S. EPA, 2000a], the case study for Tennessee streams in the Rivers and Streams Nutrient Criteria Technical Guidance*

Document [U.S. EPA, 2000b], and the letter from Tennessee Department of Environment and Conservation to Geoffrey Grubbs [TNDEC, 2000]). New York State has also presented evidence that the 25th percentile and the 75th percentile compare well based on user perceptions of water resources (NYSDEC, 2000).”

These 25th percentile values are thus characterized as criteria recommendations that could be used to protect waters against nutrient over-enrichment (USEPA, 2000). This is because the 25th percentile of the entire population was chosen by EPA to represent a surrogate for an actual reference population.

Previously, CCAMP identified reference streams in the central coast region during development of nutrient water quality criteria for the 2008 303(d) Integrated Report (Central Coast Region). However, regarding CCAMP’s reference streams, there were very few reference streams identified for Hydrologic Unit 309 (i.e., the Salinas River Watershed). Accordingly, in this report staff developed a statistical analysis of water quality data based on the aforementioned USEPA 25th percentile criteria for the aggregate population of *all* stream nutrient data within Hydrologic Unit 309 (HU 309).

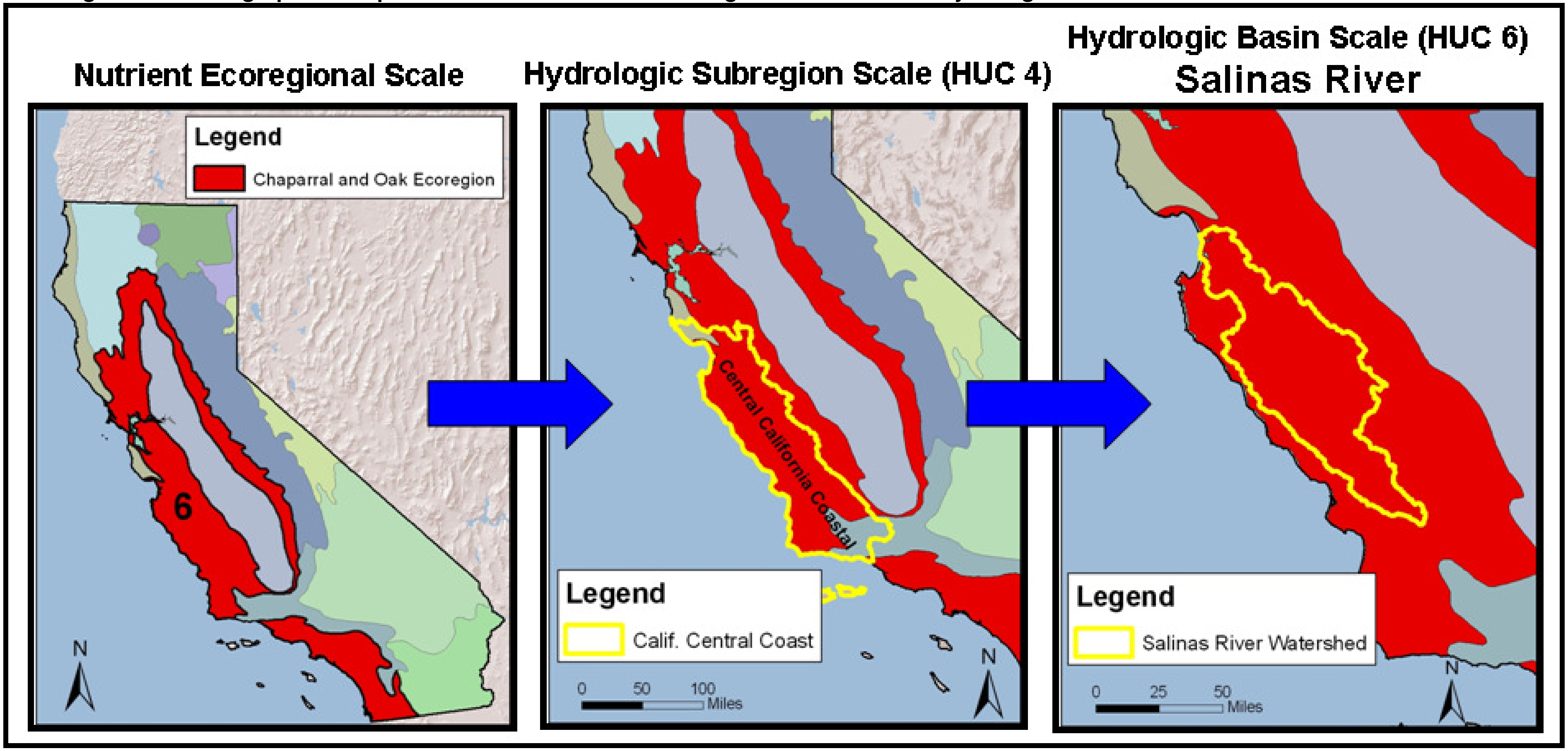
As noted in Section 7.3, USEPA has already published a 25th percentile nutrient criteria for Ecoregion III-6 (Central and Southern California chaparral and oak woodlands ecoregion). However, USEPA also notes that States may need to determine with *greater precision*, and at *smaller geographic scales*, the nutrient levels that protect aquatic life. This is because USEPA nutrient criteria developed at the ecoregional scale, may or may not be representative of more localized conditions within a given ecoregion.

Therefore, staff developed statistical 25th percentile nutrient criteria at a smaller geographic scale than the published USEPA’s ecoregional criteria. Staff reasons that developing 25th percentile nutrient data for <u>Hydrologic Unit 309</u> will provide a more valid comparison when comparing these statistical reference values to the draft NNE results that were developed in previous sections of this report.

Figure 8-10 illustrates the greater precision and smaller geographic scale at which staff developed 25th percentile criteria for this project, as compared to the scope of USEPA Ecoregion III-6 nutrient criteria. For visual reference, Hydrologic Unit 309, is equivalent to the hydrologic basin scale (HUC 6) of the USGS hydrologic unit code classification system (Figure 8-10).

In addition, many CCAMP sampling sites for Hydrologic Unit 309 are from alluvial, or valley floor stream reaches. Staff reasons that this increases the validity of the 25th percentile reference values calculated here, because valley floor or alluvial waterbodies are more representative of the project area hydrology of the lower Salinas valley.

Figure 8-10. Geographic Comparison of USEPA Nutrient Ecoregional-Scale versus Hydrologic Basin-Scale.



In tabulating data, total nitrogen in Hydrologic Unit 309 was calculated on the basis of TKN + NO_2_N + NO_3_N (per USEPA Nutrient Criteria Technical Guidance Manual, 2000). Total phosphorus was represented by total PO_4 as P (personal communication, Mary Adams, Central Coast Ambient Monitoring Program).

The location of CCAMP stream nutrient data for Hydrologic Unit 309 is shown in Figure 8-11. Figure 8-12 through 8-13 illustrate a comparison between the USEPA 25^{th} percentile nutrient criteria, and the NNE targets developed earlier in this report.

The 25^{th} percentile for total nitrogen data in Hydrologic Unit 309 is marginally lower than the NNE total nitrogen targets developed in this report. In contrast, the 25^{th} percentile for total phosphorus in Hydrologic Unit 309 is marginally higher than the NNE total phosphorus targets developed in this report. However, both the USEPA 25^{th} percentile criteria and the NNE targets developed in this report broadly illustrate that nutrient levels which are representative of relatively non-impacted reference conditions, and are at levels that are protective of aquatic habitat are at approximately a magnitude lower than numeric water quality criteria previously presented in this report for protection of drinking water supply (MUN, GWR).

It is also worth noting that the draft NNE targets, and the USEPA 25^{th} percentile criteria developed here are well within similar ranges of nutrient targets developed in other TMDLs and water quality projects within the Central and Southern California Chaparral and Oak Woodland ecoregion (see Section 8.4).

As noted previously, an important tenet of the California NNE approach (Tetra Tech 2006) is that targets should not be set lower than the value expected under natural conditions. As such, the NNE approach may require multiple lines of evidence, including but not limited to, the use of the NNE spreadsheet scoping tool. Additional lines of evidence as developed in this section of the report (e.g., utilization of USEPA percentile criteria) indicate that baseline reference conditions in the 309 Hydrologic Unit (Salinas River Watershed) may be marginally higher for total water column phosphorus than draft NNE results for total phosphorus. As such, staff may refine the provisional total phosphorus targets identified in Table 8-5, as appropriate.

Figure 8-11. Location of Nutrient Monitoring Sites in Hydrologic Unit 309 (Salinas River Watershed).

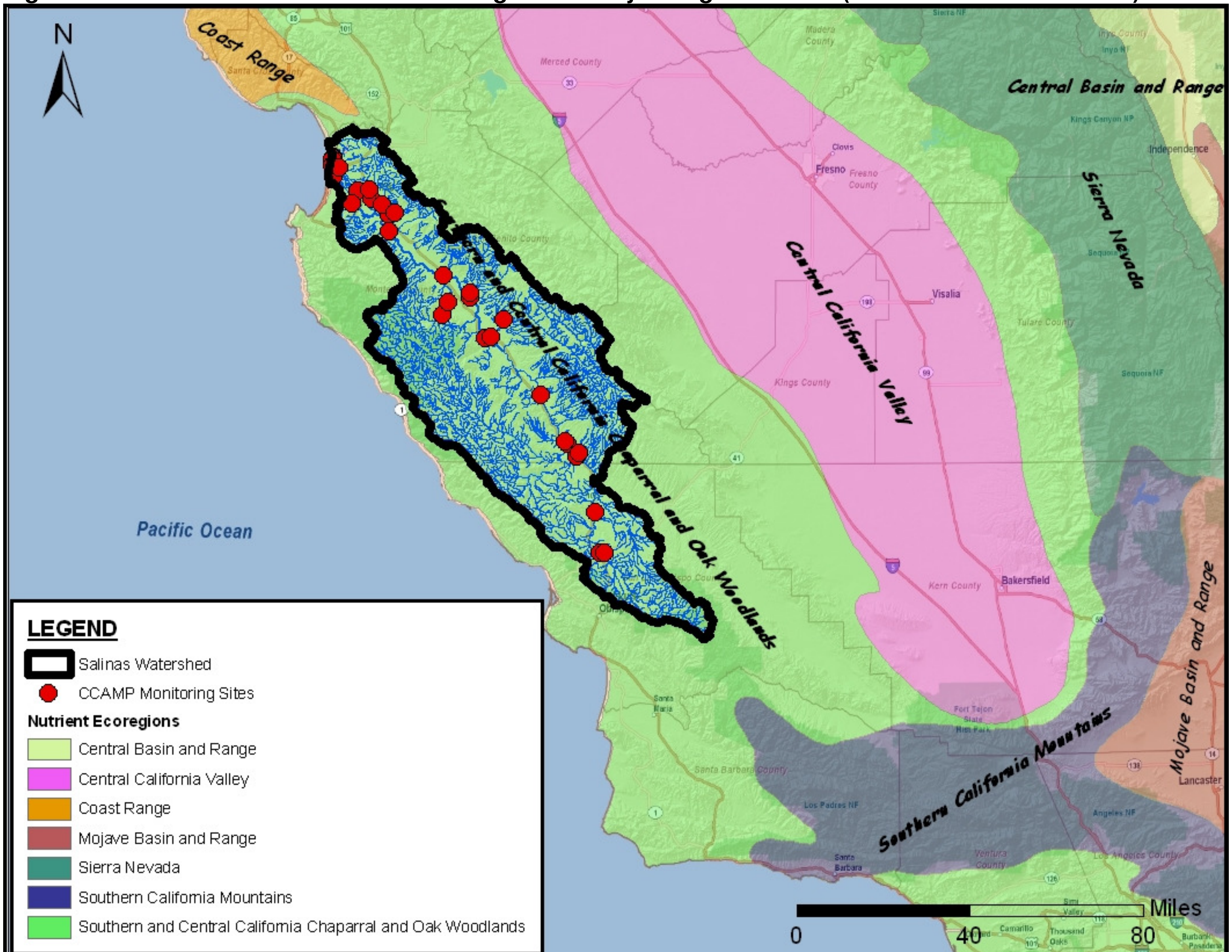
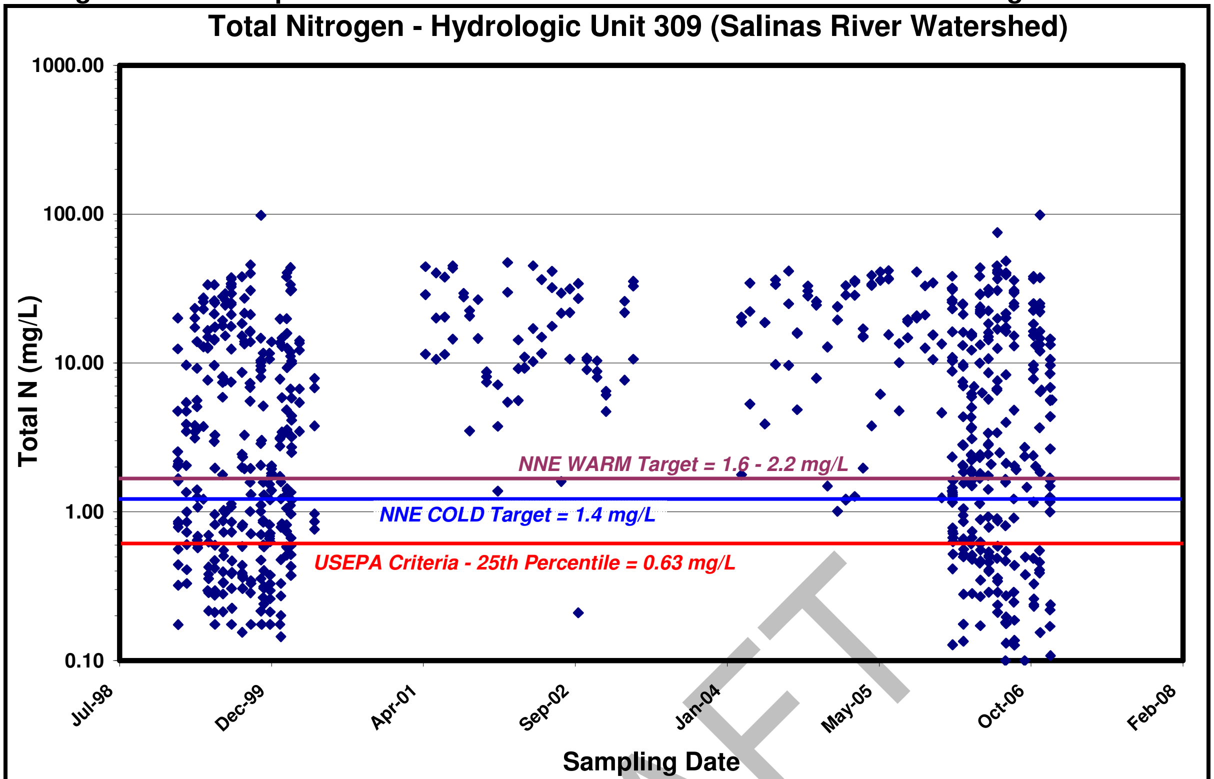


Figure 8-12. Comparison of USEPA 25th Percentile Criteria versus NNE Targets for Total N.



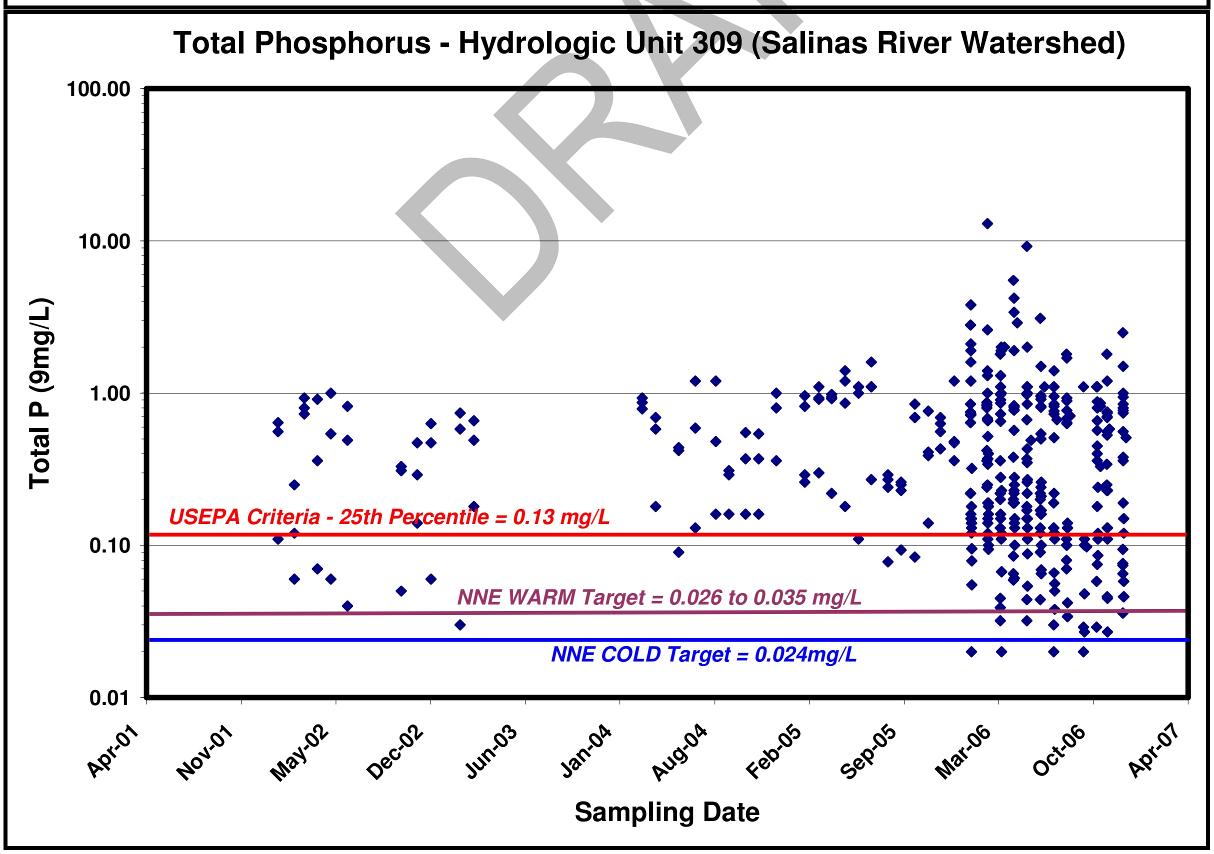


Figure 8-13. Comparison of USEPA 25th Percentile Criteria versus NNE Targets for Total P.

Finally, Table 8-7 summarizes the USEPA-recommended approaches for assessing and developing nutrient criteria, and how they were applied in this report. As noted previously, USEPA (2000) reports that a weight of evidence approach to developing nutrient criteria that "combines **any or all of the three recommended of the approaches will produce criteria of greater scientific validity."**

Table 8-7. USEPA-Recommended Approaches for Developing Nutrient Criteria.

USEPA-Recommended Approaches	Used in this Report?	Methodology
Use of **Predictive Relationships** (modeling; biocriteria)	☑	California NNE Approach
Statistical Analysis of Data	☑	USEPA-recommended statistical analysis: 25th percentile of nutrient data for stream population
Use of established concentration **thresholds from published literature**	☑	USEPA published nutrient criteria for Ecoregion III, Subecoregion 6

8.5 Summary Conclusions

Provisional draft nutrient criteria have been developed in this report in accordance with USEPA guidance, and the California NNE approach.

USEPA Guidance is outlined below:

- Streams should be classified and grouped by type or comparable characteristics (fluvial morphology, hydraulics, physical, biological or water quality attributes). No single criterion will be sufficient for each waterbody type. Classification will allow criteria to be identified on a broader scale rather than a site-specific scale.
- Nutrient criteria need to be developed to account for different waterbody processes and responses which will dictate that nutrient criteria be specific to waterbody type.
- Select variables for monitoring nutrients: Variables are measurable attributes that can be used to evaluate or predict the condition or degree of eutrophication in a waterbody. Four primary water quality attributes that must be addressed are TN, TP, chlorophyll *a* as an estimate of algal biomass, and turbidity.

Draft provisional targets for the lower Salinas River watershed presented here are similar or marginally higher when compared to USEPA's ecoregional nutrient criteria recommendations (central California chaparral and oak woodlands subecoregion), and to the Rainbow Creek Nutrient TMDL (San Diego Regional Water Quality Control Board, 2006). Also, the draft provisional targets are relatively similar to targets reported in TetraTech's pilot study for Chorro Creek nutrient NNEs (see Table 8-8). Note that TetraTech estimated 80% canopy closure (high degree of shading) in Chorro Creek, which is significantly higher than the amount of canopy shading that can plausibly be approximated in most higher order project area stream reaches of the lower Salinas valley. In general, higher canopy shading can result in higher allowable nutrient concentrations in accordance with NNE spreadsheet tool calculations.

Table 8-8. Comparison of Draft Lower Salinas River Watershed Numeric Targets to Previously Developed Targets for Ecoregion III-Subecoregion 6 Waterbodies (units = mg/L).

<table>
<tr><th>TN (Lower Salinas River Watershed)</th><th>TP (Lower Salinas River Watershed)</th><th>TN (USEPA, 2001)[A]</th><th>TP (USEPA, 2001)[A]</th><th>TN (TetraTech 2007)[B]</th><th>TP (TetraTech, 2007)[B]</th><th>TN (RWQCB-9 2006)[C]</th><th>TP (RWQCB-9, 2006)[C]</th></tr>
<tr><td>1.6 to 2.2 (WARM)</td><td>0.0265 to 0.035 (WARM)</td><td rowspan="2">0.52</td><td rowspan="2">0.03</td><td>2.9 (WARM)</td><td>0.045 (WARM)</td><td rowspan="2">1.0</td><td rowspan="2">0.1</td></tr>
<tr><td>1.4 (COLD)</td><td>0.0245 (COLD)</td><td>1.6 (COLD)</td><td>0.028 (COLD)</td></tr>
</table>

A: Criteria for Ecoregion III, subecoregion 6 (2001)
B: Chorro Creek Pilot Study for TMDL NNE report (2007)
C: Rainbow Creek Nutrient TMDL, San Diego RWQCB (2006)

As noted previously in this report, in developing the draft provisional numeric targets in this report, staff used the consensus target for response indicators (algal biomass, oxygen deficit) defining the boundary between BURC II/III. In accordance with the California NNE approach, this provides a numeric target that conservatively identifies problem conditions; i.e. there is consensus that the secondary response (e.g., algal biomass) targets used in this report provide a measure of waterbodies that are "likely impaired."

Additionally, Staff relied on USEPA nutrient criteria development technical guidance for streams. Staff used a weight of evidence approach to develop and validate draft numeric criteria by using multiple USEPA-recognized approaches: 1) predictive modeling of numeric endpoints via the California NNE approach, and 2) statistical analysis of expected reference conditions using USEPA's 25th percentile approach; 3) USEPA published nutrient criteria for Ecoregion III, Subecoregion 6. USEPA reports that using one, or more of these approaches, will produce criteria of greater scientific validity. The methods as used in this report provided marginally different results. However, all methods broadly corroborated that nutrient targets protective of aquatic habitat in the project area should be about an order of magnitude lower than well-established numeric criteria that are protective of drinking water supply uses.

As such, staff concludes that the draft, provisional nutrient targets developed here have a sufficient and adequate degree of scientific validity from an empirical perspective. However, further refinement of nutrient targets and linkage to secondary response variables may be warranted as TMDL development on this project progresses. For example as outlined in Worcester et al. (2010) and USEPA Science Advisory Board (2010) draft numeric targets for nutrients may need to be supported with a weight of evidence approach, rather than stand-alone statistical methods or Benthic Biomass Tool model outputs. The weight of evidence approach is intended to reduce uncertainty about the cause-and-effect between nutrients and biological response measures. A weight of evidence approach could use other lines of evidence for eutrophication and nutrient over-enrichment (e.g., see Table 7-2). Also, because nutrient loads, and nutrient effects can vary substantially in different seasons, refinements may include developing a temporal, seasonal (e.g., summer versus winter targets), or statistical component (e.g., annual or seasonal mean value of a suite of water quality samples) that may be embedded in the final numeric targets.

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